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MRDA

A MEDIUM RESOLUTION DATA ANALYSIS CODE

FOR THE HP2100 COMPUTER

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20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

This report describes the Medium Resolution Data Analysis Code (MRDA) which is a computer software code developed to run on the HP2100 mini-computer at the Air Force Geophysics Laboratory. The code calculates the atmosphere transmittance of radiation in the 1800 - 6000/cm^{-1} range. The code can be used for a variety of paths (horizontal, vertical, downward, to space, etc). The user has the option of using either the 1962 U.S. Standard Model atmosphere or radiosonde data. Because of size restriction on the HP2100, MRDA is divided into seven overlays. The spectral

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Abstract (Continued)

absorption coefficients, which are calculated from the AFGL compilation of molecular line parameters (HITRAN), are accessed from a data tape. The transmittance calculated for horizontal paths near sea level agree with those calculated with HITRAN, but MRDA tends to overestimate the absorption in the neighborhood of strongly absorbing lines. Some recommendations for further upgrading of the code are given.

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I INTRODUCTION

The task of generating the Medium Resolution Data Analysis (MRDA) code was undertaken to provide medium resolution predictions of atmospheric transmission and radiation. Equally important is the requirement that the software operate on the HP2100 minicomputer. This enables a direct convenient inclusion of atmospheric effects in the radiation studies being carried out at AFGL. MRDA is basically a combination of the high resolution code HITRAN[1] and the low resolution code LOWTRAN3.[2] The basic input-output structure of MRDA is similar to that of LOWTRAN3, with additions to improve its spectral resolution.

The MRDA code is now operational on the HP2100 mini-computer. Because of severe limitations on core size the code is divided into seven segments. The MRDA code correctly reproduces the spectral structure of atmospheric transmittance calculations when compared to results using HITRAN. However, MRDA tends to overestimate the absorption at higher altitudes in the spectral region near the center of a strongly absorbing line. The framework for calculating atmospheric radiation is built into the program, although these calculations are not done in the present version of MRDA.

Section II outlines the instruction format for using MRDA. In Section III a discussion of the organization of MRDA is presented along with examples of how various types of calculations are performed. Section IV discusses the capabilities of the code and its accuracy. A listing of the computer code is given in Appendix A, supplemented by a flow chart for each segment (Appendix B) and a definition of symbols (Appendix C). A listing of the program used to generate the absorption coefficients is in Appendix D.

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(1) R. A. McClatchey et al., "AFCRL Atmospheric Absorption Line Parameters," AFCRL-TR-73-0096, January 1973. 762 904.

(2) J. E. A. Sebly and R. A. McClatchey, "Atmospheric Transmittance from 0.25 to 28.5 μm: Computer Code LOWTRAN3," AFCRL-TR-0255, May 1975.

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II INSTRUCTION FOR USING MRDA

Since MRDA is very close to LOWTRAN3 in concept and operation, the inputs to the two programs are virtually identical. For this reason much of the description presented here is a paraphrase of the LOWTRAN3 operation instructions. The input medium for MRDA, instead of a card deck, is a disk JOB file. This file contains all the input information that would normally appear in the input card deck for LOWTRAN3 with a few changes. A listing of the JOB file (called MDATA) is shown in Figure 1. The many different atmospheric data contained in LOWTRAN3 are not used by MRDA. MRDA uses none of the spectral atmospheric data and, in order to conserve memory, uses only one model atmosphere. Presently, the file MDATA contains the 1962 U.S. Standard Model Atmosphere.

In general, it is only necessary to change the last four lines of the JOB file (referred to here as input lines 1-4) in order to run the program for a given problem. The formats for the last four input lines and their application will be discussed next. The user has the option of different paths (horizontal, slant, vertical, to space) and the option of reading in radiosonde data to replace the model atmosphere.

A. INPUT DATA AND FORMATS

The data necessary to specify a given problem are given on the last four lines of the JOB file. They are as follows:

Input Line 1	MODEL, IHAZE, ITYPE, LEN, JP, IM, NLDAT, IRAD	FORMAT (7I3)
Input Line 2	H1, H2, ANGLE, RANGE, BETA, VIS	FORMAT (6F 10.3)
Input Line 3	V1, V2, DV	FORMAT (3F 10.3)
Input Line 4	DVM	FORMAT (F 10.2)

Definitions of the above quantities will be discussed in Section B.

If the quantity MODEL given on input line 1 is set equal to 0 or 2 (which means meteorological data are used as input to the program), then the above card sequence (and format for input line 2) is changed. These cases will be described in Section C.

```
MDATA  T=00004 IS ON CR00001 USING 00018 BLKS R=0078

0001  :JOB,MRDA
0002  :RU,MRDA
0003    6 34
0004    2.830E+03 1.245E+03 5.374E+02 2.257E+02 1.193E+02 8.992E+01 6.341
0005    6.073E+01 5.822E+01 5.679E+01 5.320E+01 5.589E+01 5.159E+01 5.052
0006    4.514E+01 4.460E+01 4.317E+01 3.636E+01 2.669E+01 1.935E+01 1.456
0007    8.831E+00 7.434E+00 2.239E+00 5.893E-01 1.551E-01 4.084E-02 1.078
0008    1.970E-08-0.
0009    1.379E+04 5.034E+03 1.845E+03 6.735E+02 2.454E+02
0010       0.0 1.013E+03 288.1      5.9E+00     5.4E-05
0011       1.0 8.986E+02 281.6      4.2E+00     5.4E-05
0012       2.0 7.950E+02 275.1      2.9E+00     5.4E-05
0013       3.0 7.012E+02 268.7      1.8E+00     5.0E-05
0014       4.0 6.166E+02 262.2      1.1E+00     4.6E-05
0015       5.0 5.405E+02 255.7      6.4E-01     4.6E-05
0016       6.0 4.722E+02 249.2      3.8E-01     4.5E-05
0017       7.0 4.111E+02 242.7      2.1E-01     4.9E-05
0018       8.0 3.565E+02 236.2      1.2E-01     5.2E-05
0019       9.0 3.080E+02 229.7      4.6E-02     7.1E-05
0020      10.0 2.650E+02 223.2      1.8E-02     9.0E-05
0021      11.0 2.270E+02 216.8      8.2E-03     1.3E-04
0022      12.0 1.940E+02 216.6      3.7E-03     1.6E-04
0023      13.0 1.658E+02 216.6      1.8E-03     1.7E-04
0024      14.0 1.417E+02 216.6      8.4E-04     1.9E-04
0025      15.0 1.211E+02 216.6      7.2E-04     2.1E-04
0026      16.0 1.035E+02 216.6      6.1E-04     2.4E-04
0027      17.0 8.850E+01 216.6      5.2E-04     2.8E-04
0028      18.0 7.565E+01 216.6      4.4E-04     3.2E-04
0029      19.0 6.467E+01 216.6      4.4E-04     3.5E-04
0030      20.0 5.529E+01 216.6      4.4E-04     3.8E-04
0031      21.0 4.729E+01 217.6      4.8E-04     3.8E-04
0032      22.0 4.047E+01 218.6      5.2E-04     3.9E-04
0033      23.0 3.467E+01 219.6      5.7E-04     3.8E-04
0034      24.0 2.972E+01 220.6      6.1E-04     3.6E-04
0035      25.0 2.549E+01 221.6      6.6E-04     3.4E-04
0036      30.0 1.197E+01 226.5      3.8E-04     2.0E-04
0037      35.0 4.746E+00 236.5      1.6E-04     1.1E-04
0038      40.0 2.871E+00 253.4      6.7E-05     4.9E-05
0039      45.0 1.491E+00 264.2      3.2E-05     1.7E-05
0040      50.0 7.978E-01 270.6      1.2E-05     4.0E-06
0041      70.0 5.520E-02 219.7      1.5E-07     8.6E-08
0042     100.0 3.008E-04 210.0      1.0E-09     4.3E-11
0043    99999.                210.0
```

Figure 1. Example of the MRDA JOB File

```
     .20 .28600 .09530    .25 .28000 .05660    .31 .26200 .02060    .34
     .49 .18500 .01050    .51 .17600 .01000    .63 .14600 .00914    .69
     .86 .10800 .01020   1.06 .08910 .01080   1.54 .05790 .00924   2.00
    2.50 .02660 .00369   2.70 .02670 .00988   3.00 .02240 .00487   3.20
    3.39 .02090 .00222   3.50 .02100 .00171   3.75 .01950 .00143   4.00
    4.50 .01670 .00248   5.50 .01360 .00295   6.00 .01190 .00360   6.50
    7.20 .01330 .00629   7.90 .00784 .00504   8.20 .00809 .00702   8.50
    8.70 .02190 .01180   9.00 .02380 .01310   9.20 .02350 .01430   9.50
   10.00 .01570 .00698  10.59 .01350 .00549  11.00 .01220 .00439  13.00
   14.80 .00827 .00464  15.00 .01010 .00691  17.20 .01100 .00607  18.50
   20.00 .01010 .00587  25.00 .00878 .00565  27.90 .00821 .00562  30.00
   2.93E-04 3.86E-04 5.09E-04 6.56E-04 8.85E-04 1.06E-03 1.31E-03 1.
   2.27E-03 2.73E-03 3.36E-03 3.95E-03 5.46E-03 7.19E-03 9.00E-03 1.
   1.36E-02 1.66E-02 1.96E-02 2.16E-02 2.36E-02 2.63E-02 2.90E-02 3.
   3.40E-02 3.66E-02 3.92E-02 4.26E-02 4.60E-02 4.95E-02 5.30E-02 5.
   6.00E-02 6.30E-02 6.60E-02 6.89E-02 7.18E-02 7.39E-02 7.60E-02 7.
   8.08E-02 8.39E-02 8.70E-02 9.13E-02 9.56E-02 1.08E-01 1.20E-01 1.
   1.52E-01 1.60E-01 1.69E-01 1.60E-01 1.51E-01 1.37E-01 1.23E-01 1.
   1.16E-01 1.14E-01 1.12E-01 1.12E-01 1.11E-01 1.11E-01 1.12E-01 1.
   1.13E-01 1.12E-01 1.09E-01 1.07E-01 1.02E-01 9.90E-02 9.50E-02 9.
   8.65E-02 8.20E-02 7.65E-02 7.05E-02 6.50E-02 6.10E-02 5.50E-02 4.
   4.50E-02 4.00E-02 3.75E-02 3.50E-02 3.10E-02 2.65E-02 2.50E-02 2.
   1.95E-02 1.75E-02 1.60E-02 1.40E-02 1.20E-02 1.05E-02 9.50E-03 9.
   8.00E-03 7.00E-03 6.50E-03 6.00E-03 5.50E-03 4.75E-03 4.00E-03 3.
   3.50E-03 3.00E-03 2.50E-03 2.25E-03 2.00E-03 1.85E-03 1.70E-03 1.
   1.50E-03 1.50E-03 1.54E-03 1.50E-03 1.47E-03 1.34E-03 1.25E-03 1.
   9.06E-04 7.53E-04 6.41E-04 5.09E-04 4.04E-04 3.36E-04 2.86E-04 2.
   1.94E-04 1.57E-04 1.31E-04 1.02E-04 8.07E-05
   0.23 .187 .147 .117 .097 .087 .10  .120 .147 .174 .20  .24  .28
    0  2  1     1
          5.0     1013.0      26.85       40.0                 .5E-5
    2300.000  2310.000      5.000
         0.50
   :EOJ
```

Figure 1. (cont.) Example of the MRDA JOB File

B. BASIC INSTRUCTIONS

The various quantities to be specified on each of the four control cards are discussed in this section

1. Input Line 1 MODEL, IHAZE, ITYPE, LEN, JP, IM, NLDAT, IRAD

The parameter MODEL either selects the model atmosphere or specifies that meteorological data are to be used in place of the standard model. IHAZE specifies whether aerosol attenuation is to be included in the calculation or not. For any problem the atmospheric path must be specified as one of three types according to ITYPE and LEN. The rest of the quantities given on input line 1 (which can be left blank if not required) provide the user with options to suppress printing (JP), and to input a new model atmosphere (IM, NLDAT). The options for the above parameters and their uses are stated and described in detail below:

MODEL = 0 if meteorological data are specified (for horizontal paths only)*

= 1 selects 1962 US STANDARD Model Atmosphere

= 2 if a new model atmosphere (or radiosonde data) is to be instered.*

MRDA currently uses only the 1962 U.S. Standard Model atmosphere. If any of the other LOWTRAN3 model atmospheres are desired a new JOB file can be created with the appropriate model atmosphere in place of the U.S. Standard and setting MODEL = 1. MRDA will still identify the model as the 1962 U.S. Standard. Since MRDA assumes the earth's radius is 6371.23 km this may introduce minor differences when a model other than the U.S. Standard atmosphere is used.

IHAZE = 0 means no aerosol attenuation included in the calculations.

IHAZE = 1 or 2 if aerosol attenuation is required (see also Input Line 2).

If IHAZE is set equal to 1 or 2 and visual range (VIS) is not specified on Input Line 2, then the program will automatically select visual ranges of 23 km or 5 km, respectively.

---

* In these cases the format for Input Line 2 changes (see nonstandard conditions) Section C

ITYPE = 1 for a horizontal (constant pressure) path.

= 2 for a vertical or slant path between two altitudes.

= 3 for a vertical or slant path to space.

The TYPE 1 path should not be confused with a long 90^{o} path where the local height at the end of the trajectory is significantly different from the beginning height. In such a case, specify the path according to ITYPE = 2 (see Section B2)

LEN = 0 for normal operation of program.

LEN = 1 selects the downward TYPE 2 path shown in Figure 2(e).

The parameter LEN can be ignored (that is, left blank) for the majority of cases. It need only be used for a downward looking path (H2 > H1) when two paths are possible for the same input parameters. In such a case, a computer printout statement will be given indicating that the user has two choices for the problem and that the shorter path (see Figure 2(d)) has been executed. Set LEN = 1 for the longer case.

JP = 0 for normal operation of program.

JP = 1 to suppress printing of transmittance table

IM = 1 when radiosonde data are to be read in initially

IM = 0 for normal operation of program or when subsequent calculations are to be run with MODEL = 2

NLDAT = Number of levels to be read in for MODEL = 2

Note that IM and NLDAT are only used when MODEL = 2.

IRAD is a flag to indicate whether or not a radiation calculation is to be performed and is defined as indicated below.

IRAD = 1 perform radiation calculation.

IRAD = 0 do not perform radiation calculation.

Only the IRAD = 0 option should be used in the present version of MRDA! In the case of IRAD = 1 an additional input is required between the first and second input lines. This input is as follows:

EMISS, TBACK FORMAT (2F 10.3)

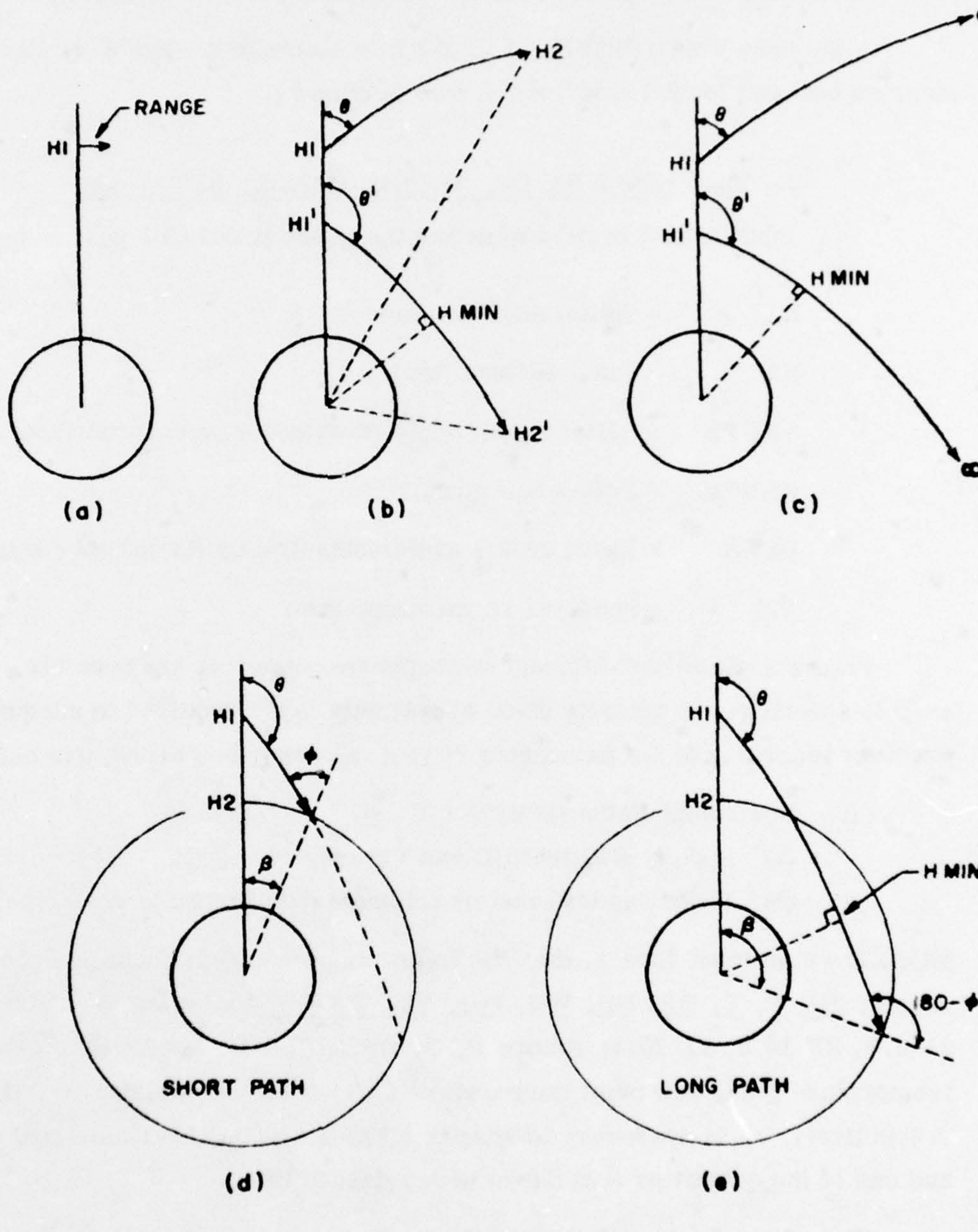

Figure 2. Geometrical Path Configuration for: (a) Horizontal Paths (Type 1), (b) Slant Paths Between Two Altitudes H1 and H2 (Type 2), and (c) Slant Paths to Space (Type 3). For downward looking paths where HMIN < H2 < H1, two trajectories are possible as indicated in (d) and (e). From Reference (2).

EMISS and TBACK define the emissivity and temperature of a background radiation source located at the beginning of the atmospheric path. TBACK is in units of ^{o}K.

In the case where MODEL = 2, the new atmosphere (model or radiosonde data) is inserted between Input Lines 1 and 2 (see Section C).

2. Input Line 2 HI, H2, ANGLE, RANGE, BETA, VIS

Input Line 2 is used to define the geometrical path parameters for a given problem.

H1	= Initial altitude (km)
H2	= Final altitude (km)
ANGLE	= Initial zenith angle (degrees) as measured from H1
RANGE	= Path length (km)
BETA	= Earth centre angle subtended by H1 and H2 (degrees)
VIS	= Sealevel visual range (km)

Figure 2 shows the different atmospheric paths that are possible. It is not necessary to specify every quantity given above; only those required to adequately describe the problem according to the parameter ITYPE (as described below) are needed.

(1) Horizontal Paths (ITYPE = 1)

(a) Specify H1, RANGE and VIS only

(b) If nonstandard meterorological data are to be used, that is, if

MODEL = 0 on Input Line 1, then the following parameters must be specified on Input Line 2: H1, P, T, DP, RH, WH, WO, VIS, RANGE according to FORMAT (3F 10.3, 2F 5.1, 2E 10.3, 2F 10.3), where P, T, DP, RH, WH, and WO are the pressure (mb), temperature (^{o}C), dew point temperature (^{o}C), relative humidity (%), H_2O density (gm m^{-3}), respectively. It is necessary to specify all of the quantities underlined with a full line and one of the quantities underlined with a dashed line.

(2) Slant Paths to Space (ITYPE = 3)

specify H1, ANGLE and VIS

(3) Slant Paths Between Two Altitudes (ITYPE = 2)

(a) Specify H1, H2, ANGLE, and VIS; or

(b) Specify H1, ANGLE, RANGE, and VIS; or

(c) Specify H1, H2, RANGE, and VIS.

For cases (b) and (c), the program will calculate H2 and ANGLE respectively, assuming no refraction and then proceed as for case (a). This method of defining the problem should be used when refraction effects are not important, e.g., for ranges of a few tens of km at zenith angles less than 80°. It can also be used for larger angles (including 90°) provided that the path lies within one atmospheric layer. Slant paths to space (ITYPE = 3) or between two altitudes (ITYPE = 2) in which both ANGLE and RANGE are not defined, are not possible in MRDA. In LOWTRAN3 these paths require the calculation of the initial zenith angle of the path by use of subroutine ANGLE. MRDA does not contain this routine; thus these paths are not allowed. If this case is attempted, an error message will be printed and execution halted.

In the case where MODEL = 2 the new model atmosphere (or radiosonde data) is inserted between Input Lines 1 and 2 (see Section C).

3. Input Line 3 V1, V2, DV

The spectral range over which transmittance data are required and the spectral increments at which the continuum calculations are to be made are given by:

V1 = initial frequency in wave numbers (cm^{-1})

V2 = final frequency in wave numbers (cm^{-1}) where V2 > V1

DV = frequency increment (or step size) (cm^{-1}) for continuum calculations.

(Note that $\nu = 10^4/\lambda$ where ν is the frequency in cm^{-1} and λ is the wavelength in microns, and that DV can only take on values which are a multiple of $5 cm^{-1}$.)

4. Input Line 4 DVM

The variable DVM defines the spectral steps at which the medium resolution calculations are done and the wavenumber interval of the final output. A value of $0.05 cm^{-1}$ should be used, because it agrees with the spectral resolution of the library tape.

C. ATMOSPHERIC MODEL

Three options are available if atmospheric transmittance calculations are required for nonstandard conditions. Here nonstandard refers to conditions other than those specified by the model atmosphere in MDATA. The three options enable the reader to insert:

(1) His own model atmosphere(s) in place of the standard model, provided that the data are in exactly the same format and are specified at the same altitudes as the latter. In this case the appropriate print statements in MRDA (that identify the atmospheric model used) must be changed correspondingly.

(2) An additional atmospheric model (MODEL=2), which can be in the form of radiosonde data. The data need not be specified at the same altitudes as in the standard models.

(3) Meteorological conditions for a given horizontal path calculation (MODEL = 0 case). This was discussed in Section B-2 and will not be repeated here.

The first of these options requires the most effort and needs no further discussion here.

1. Additional Atmospheric Model (MODEL = 2)

As stated in Section B-2, a new model atmosphere can be inserted between Input Line 1 and 2 provided the parameters MODEL and IM are set equal to 2 and 1 respectively on Input Line 1. The number of atmospheric levels to be inserted (NLDAT) must also be specified on Input Line 1. The appropriate meteorological parameters and format for the atmospheric data are given below.

Z, P, T, DP, RH, WH, WO, AHAZE (FORMAT (3F 10.3, 2F 5.1, 2E 10.3, 2F 10.3))

where

Z	=	altitude (km)
P	=	pressure
T	=	ambient temperature (^{o}C)
DP	=	dew point temperature (^{o}C)
RH	=	relative humidity (%)
WH	=	water vapor density (gm m^{-3})
WO	=	ozone density (gm m^{-3})
AHAZE	=	aerosol number density (cm^{-3})

Note that it is only necessary to specify those quantities underlined with a full line and either of the quantities underlined with the dashed line.

If the aerosol number density was not measured as a function of altitude and the reader wishes to include aerosol attenuation in the calculation, set IHAZE = 1 on Input Line 1. In this case MRDA will use the aerosol models already contained in the program and interpolate to give aerosol number density values at the same altitudes as the radiosonde (or new model atmosphere) data. The program will then look for a sea level visual range (VIS) to be specified on Input Line 2. If VIS is not specified, a 23 km sea level visual range will be assumed. If aerosol attenuation is not required, set IHAZE = 0 on Input Line 1 as before.

D. RUNNING MRDA

As already mentioned all the inputs for MRDA are contained within the JOB file MDATA. Before running MRDA the HP2100 system should be in the normal keyboard mode since the JOB file uses FMGR. To execute MRDA simply type

*RUN, JOB, MD, AT, A

Before actually running MRDA two things should be done. First mount the appropriate MRDA input tape containing the spectral extinction coefficients corresponding to the frequencies of interest on UNIT 0. Second, depending on the value of IRAD, MRDA uses 1 or 2 disk files (TRAN1 and TRAN2). If the previous MRDA run ended other than normally, one or both of these files may still exist in the directory and should be purged before running MRDA once again. The output from MRDA will appear on the line printer.

*Any JOB file with the structure of MDATA (possibly) containing a different model atmosphere could just as wil be used.

III MRDA DESCRIPTION

A. DESCRIPTION OF MRDA SOFTWARE

MRDA is designed to make medium resolution atmospheric transmission calculations in the range of 1800 to 6000 cm^{-1} over a wide variety of geometrical paths. These calculations are carried out within MRDA in three stages. The first part of the calculation consists of predicting the continuum transmissions (H_2O, N_2, molecular scattering) along with aerosol absorption for the chosen path and wavenumber interval. These calculations are carried out by what is essentially LOWTRAN3 with all the spectral calculations removed. In the process of computing the continuum results, intermediate values are saved for later use. For example the pressure, temperature and altitude of each layer in the geometric path are stored. In addition, if a radiation calculation is requested (IRAD = 1) the transmission through each layer is also stored in a disk file named TRAN1. Finally the atmospheric concentration of H_2O and O_3 in each layer along with the molecular density (of all gases) for the particular path through each layer is computed and saved.

In the second part of MRDA the medium resolution spectral calculations are performed. The atmospheric information needed to carry out these calculations have been transfered from part 1. Three magnetic tapes contain a complete library of extinction coefficients necessary to compute the medium resolution results. These tapes are generated using the high resolution transmission program (HITRAN). The tapes are organized in 10 cm^{-1} blocks over the 1800 to 6000 cm^{-1} range that MRDA operates. In each wavenumber block exctinction coefficients for 6 molecular species at 9 pressure-temperature points are defined at wavenumbers which depend on the structure of the absorption spectra for the particular species in that wavenumber block. For each species the wavenumbers were chosen so as to define the spectra by identifying the strongest lines in the region. The extinction coefficients are then calculated at the line center, points slightly removed from the line center and midway between adjacent strong lines.

Using the information from part 1, the library tape data, and possibly the disk file TRAN1, the program calculates the total spectral transmission for the geometric path and frequencies defined by the input. In order to obtain the extinction coefficient from the tape at the particular pressure, temperature and frequency required, the program performs linear interpolations over the pressure-temperature matrix defined on the tape and then over frequency. Once having calculated the total transmission at a particular

frequency, that frequency, the transmission and radiation results are written to a disk file TRAN2.

Part 3 of the MRDA software combines the continuum and medium resolution results The continuum results from part 1 are linearly interpolated to obtain transmission values at the medium resolution frequencies. Finally the total transmission is computed at the medium resolution frequencies and written to a disk file for later use.

B. PROGRAM ORGANIZATION

Structurally MRDA is composed of 7 separate software segments or overlays. As described in Section A the 7 segments can be combined into 3 well defined parts. Part 1 (modified LOWTRAN3) consists of segments 1 through 5. Part 2 is segment 6 and part 3 segment 7. A complete listing of all segments and subroutines is shown in Appendix A. Appendix B contains a segment by segment detailed logic flow diagram for MRDA. Appendix C has a description of the variables used in each segment.

To improve the readability and ease in following the logic with MRDA, a particular notational convention for indices has been followed throughout. This convention is outlined below:

Index variables

- I - frequency index
- L - atmospheric level number. 0 to NL
- LL - layer number, numbered sequencially along the geometric path
- K - species index

In addition many variables beginning with I, L, or K refer to quantities related to these indicies.

C. MRDA LIBRARY TAPES

The MRDA Library tapes contain the spectral absorption coefficients for the six atmospheric species which have significant absorption in the 1800 - 6000 cm^{-1} region. The species are: H_2O, CO_2, O_3, N_2O, CO and CH_4. The absorption coefficients are calculated at the selected (P, T, ν) points and then written onto a tape that is accessed by MRDA. The CDC6600 computer at AFGL was used to generate the MRDA tapes.

1. Choice of Spectral Absorption Coefficients

Because of the severe constraint on the amount of available storage on the HP2100, the data in the MRDA library tape are organized so as to define the absorption spectra for the species in as compact a form as possible. Thus nine pressure-temperature (P, T) points are used to describe the atmosphere, and the total number of wavenumbers points within each block is limited to 250.

The choice of the (P,T) points is based on the expected range of atmospheric (P, T) values. Figure 3 shows the (P, T) profile of the U.S. Standard Model Atmosphere, the estimated limits of (P, T) variability, and illustrative radiosonde data taken from several AFGL Teal Ruby Missions.[3] The heavy dots within the circles show the nine (P, T) points at which the spectral absorption coefficients are calculated. Pressure-temperature points for pressures below 100 mb are not included in the tape at this time due to the problems with the spectral structure of the transmittance at these higher altitudes.

A considerable savings in the total number of wavenumber points at which the spectral absorption coefficients must be stored is obtained by identifying the stronger spectral lines within each wavenumber block. When one or more of the species have no strong lines within a block, the absorption coefficients are calculated at only four points. After locating the strong peaks, the extinction coefficients are calculated at the peak, at points ± 0.05 cm^{-1} removed from the peak, and at a point half way between two adjacent peaks. The spectra from one strong line to the next are described by five points. Between these points the spectral absorption coefficients are obtained by linear interpolation.

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3. B. Sandford, et al., "Aircraft Signatures in the Infrared 1.2 to 5.5 Micron Region," AFGL-TR-76-0133, Air Force Geophysics Laboratory (OPR), Hanscom AFB, Mass. 01731, (June, 1976)

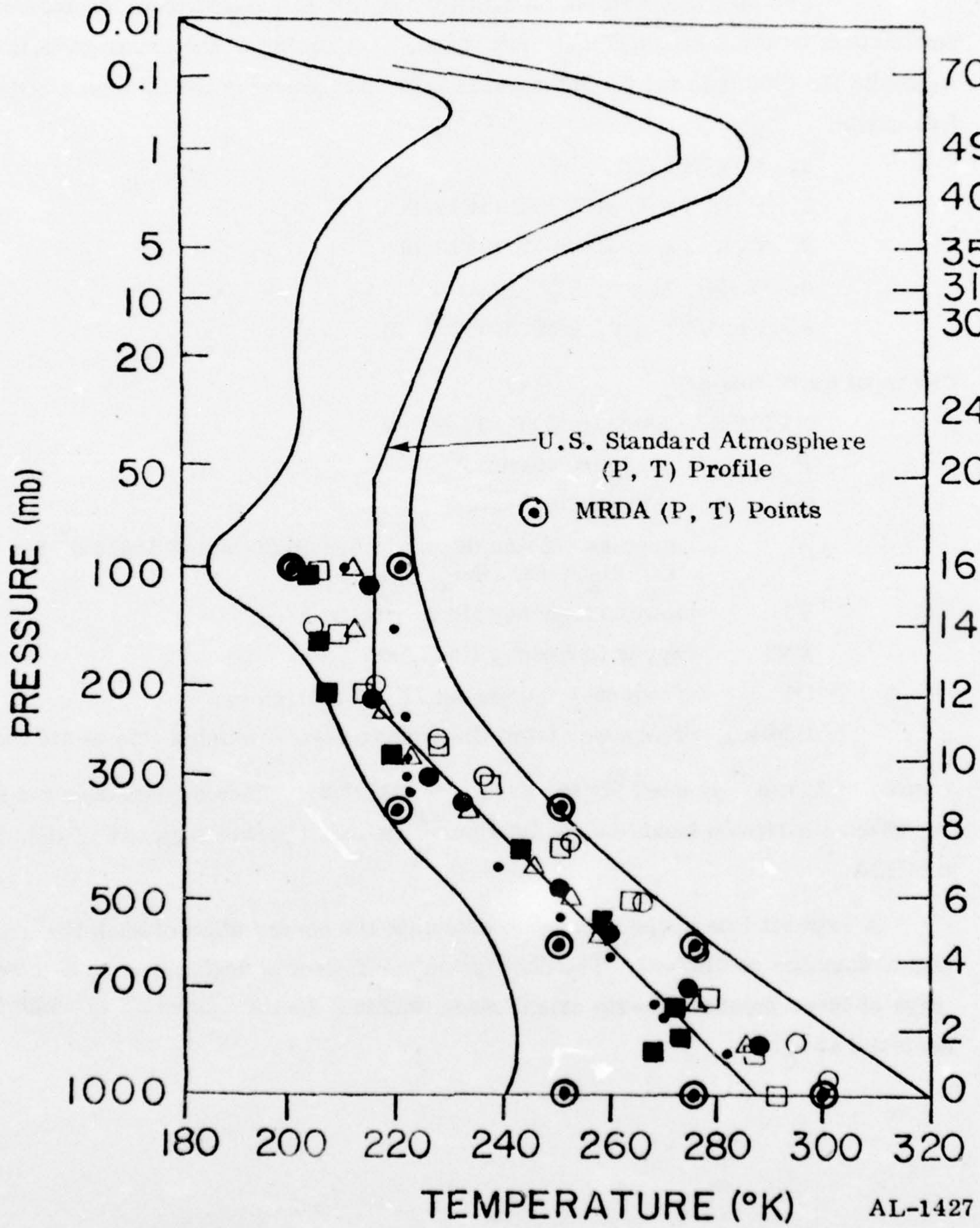


Figure 3 Temperature and pressure variations of the atmosphere. Radiosonde data from several Teal Ruby Missions are indicated. The outer lines indicate the approximate range of atmospheric temperature fluctuations. The center line is the U.S. Standard Atmosphere.

2. Calculation of the Spectral Absorption Coefficients

The spectral absorption coefficients are calculated from the molecular line parameters on the AFGL HITRAN Data Tape.[1] A listing of the program is given in Appendix D. The data for the input parameters are given by the following sequence of five cards:

1. NPTPTS (I2)
2. P (I), I = 1, NPTPTS (8E10.0)
3. T (I), I = 1, NPTPTS (8E10.0)
4. W (M), M = 1, 7 (7E10.3)
5. V1, VV2, DV, BOUND (6F10.3)

The input quantities are:

NPTPTS = number of (P, T) points

P = pressure values

T = temperature values

W = species column density = 0.269E20 molecules/cm^2 for (H_2O, CO_2, O_3, N_2O, CO, CH_4, O_2)

V1 = lower frequency limit, cm^{-1}

VV2 = upper frequency limit, cm^{-1}

DV = frequency increment, fixed at 0.05 cm^{-1}

BOUND = frequency from line center beyond which a line is not included, cm^{-1}

A value of 20 cm^{-1} is used for the parameter BOUND. Since oxygen does not have any important absorption bands below 6000 cm^{-1}, it is not included as one of the six species in MRDA.

A Lorentz line shape is used to calculate the contribution of each line to the spectral absorption coefficient. The absorption coefficient at each value ν_0 is a weighted average of three monochromatic calulations within a spectral interval of width 0.05 cm^{-1} centered at ν_0.

IV DISCUSSION

The atmospheric transmission code MRDA is operational on the HP2100 minicomputer. The software has been written in a format which allows the user considerable flexibility in his choice of atmospheric conditions and paths for transmittance calculations. In the regions with absorbing molecular lines, MRDA reproduces the correct spectral strucutre of the atmospheric transmittance and generally gives good quantitative predictions. However, as discussed below, values of the transmittance calculated by MRDA for atmospheric paths where the pressure is less than 600 mb is low in the immediate region of a strong absorbing line. This indicates that further study into improving the parameterization of the extinction coefficients at higher altitudes is needed. The structure of the HP2100 software code is designed with sufficient generality so that changes in the parameterization of the extinction coefficients are quite easily incorporated.

A. LOW RESOLUTION TRANSMITTANCE

The low resolution transmittance is calculated in the same manner as LOWTRAN3. Included are the contributions due to:

- 4μm H_2O continuum,
- 5μm N_2 continuum,
- Aerosol Scattering, and
- Molecular Scattering

Transmittance calculations by the MRDA code have been compared to those calculated by LOWTRAN3 and have been found to be in exact agreement.

B. ATMOSPHERIC PATHS

MRDA is designed to handle a variety of atmospheric paths:

- Paths to space, horizontal paths, and slant paths (upward or downward).

The identification and treatment of these paths are similar to those in LOWTRAN3. However, the high spectral resolution part of the calculation requires that the absorber amount for each atmospheric layer be considered, not just the total equivalent sea level absorber for the entire path. In MRDA, these absorber amounts are calculated in segments three,

four and five and stored in the matrix WW. They are passed on to segment six in the matrix WGAS. Because the concentrations of water vapor and ozone vary independently of the concentrations for the well mixed gases, they are also calculated and passed on in the matrices WH2O and WO3, respectively. These quantities are calculated and stored for all atmospheric paths.

C. HIGH RESOLUTION TRANSMITTANCE

The transmittance due to the spectral structure of absorption by the atmospheric gases is calculated in segment six. Basically, the calculation depends on two different inputs: the amount of an absorbing species along a segment of the path and the extinction coefficient for that species at the temperature and pressure of the segment. The total transmittance is then the product of the transmittances for all the segments. The results at each wavenumber are both printed out and stored on disk for later use.

For verification of the high resolution transmittance calculations, comparisons were made to calculations made using the HITRAN data tapes. The HITRAN calculations were done every 0.01 cm^{-1} and degraded to a resolution of 0.1 cm^{-1} by using a triangular slit function of half-width 0.1 cm^{-1}. Horizontal paths were used that had a constant amount of absorbing species (10^{20} molecules). The transmittance was calculated at several different temperatures and pressures in the spectral interval 2300-2310 cm^{-1}, which has strong CO_2 absorption.

At lower altitudes the agreement between transmittances calculated by HITRAN and MRDA was good. The regions of both strong and weak absorption were calculated properly by MRDA. The agreement was generally to within 10%; when the transmittance is very small (less than 0.10), the difference would become much larger. This is because the line shape in not sampled as extensively in MRDA as in HITRAN. As seen in Figure 4 MRDA reproduces the overall spectral structure of the transmittance calculated by HITRAN.

At higher altitude the agreement between MRDA and HITRAN is not as good because MRDA overestimates the absorption due to strong lines. Figure 5 shows the transmittance calculated by MRDA and HITRAN for a horizontal path at 500 mb pressure and 260°K temperature. Figure 6 shows a similar transmittance at 100 mb and 220°K. This indicates that further investigation into the calculation and storage of the spectral absorption coefficients is required. The initial choice of the extinction coefficients was determined by the requirement

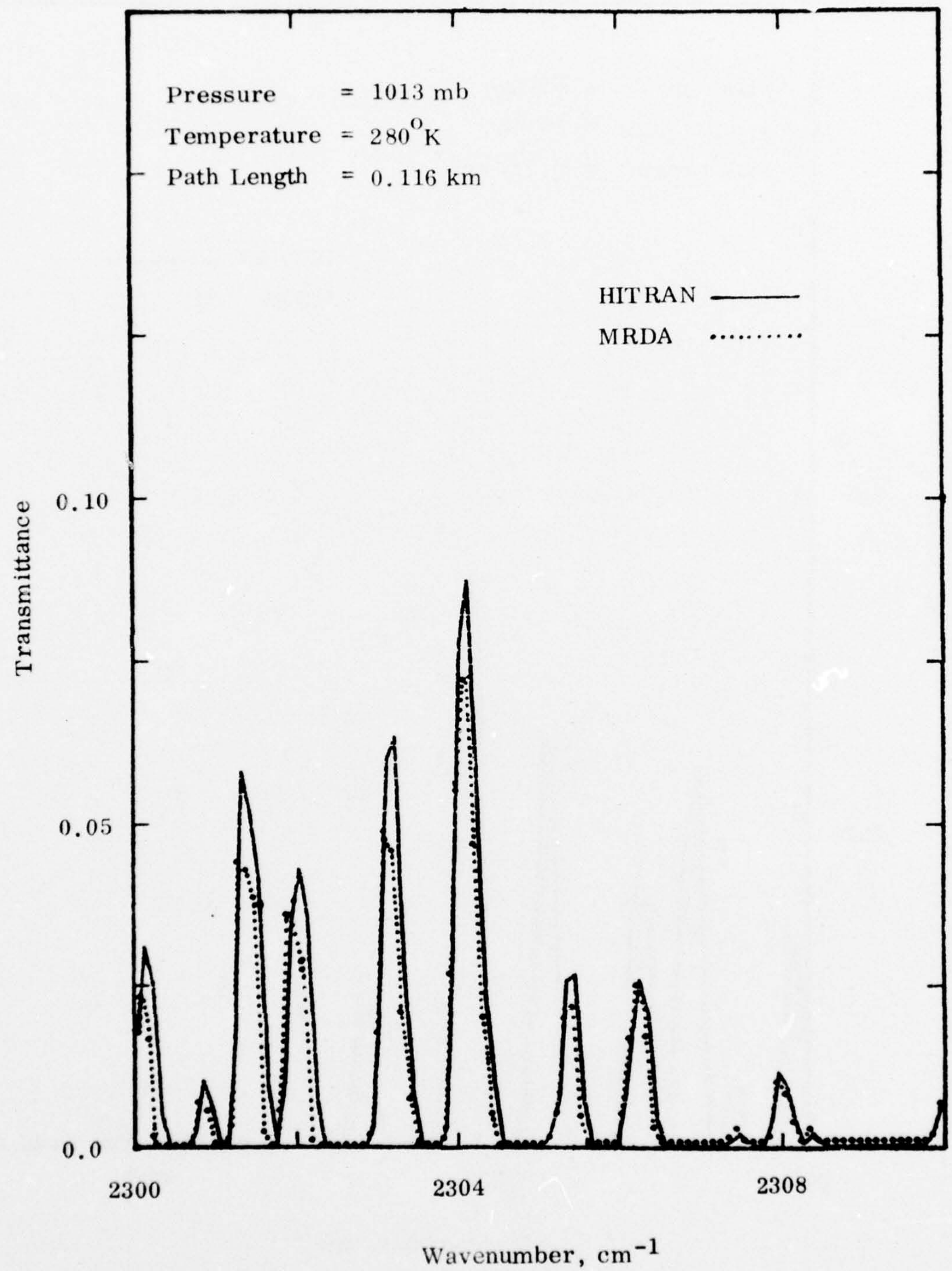


Figure 4. Comparison of MRDA and HITRAN Transmittance Calculations at 1013 mb Pressure

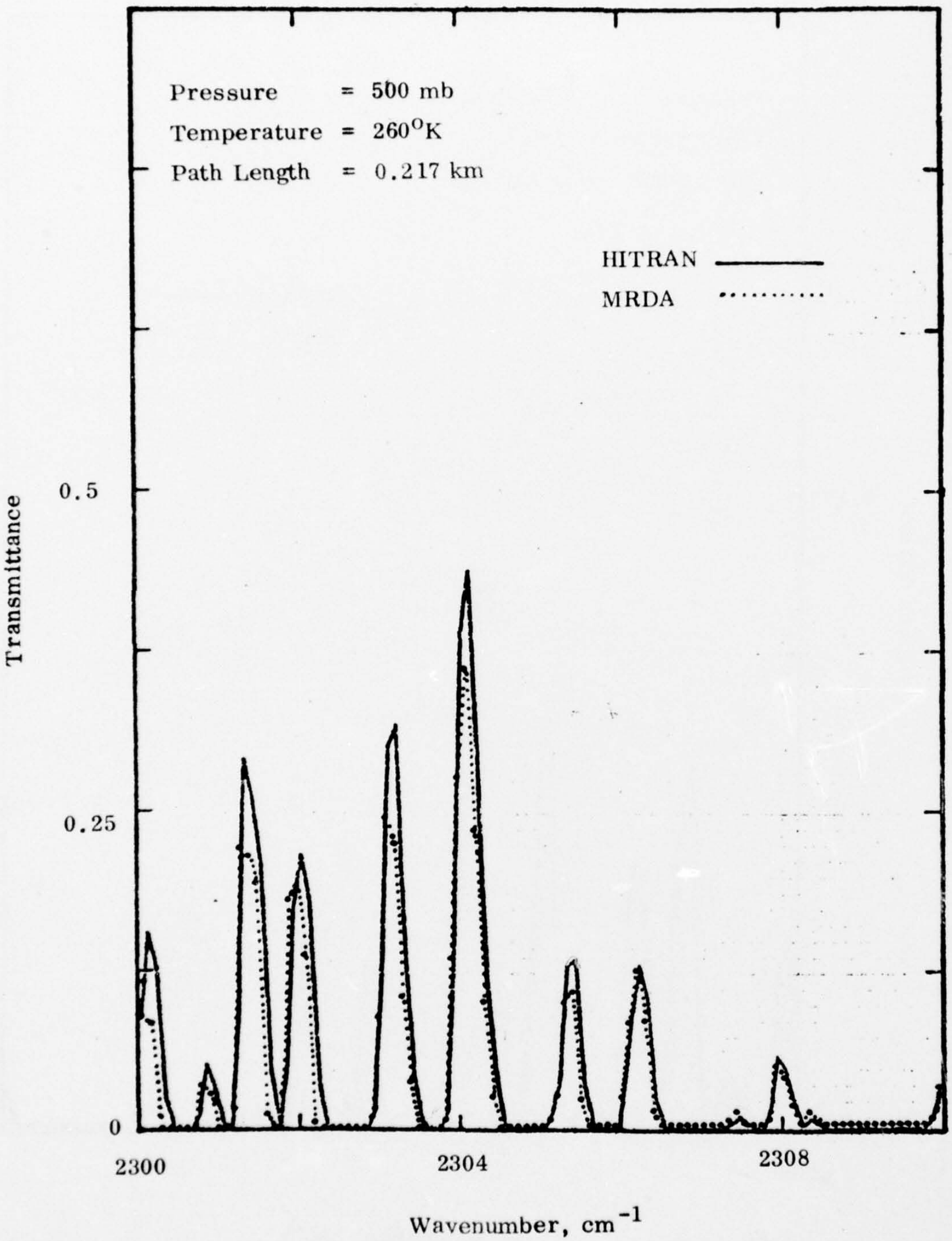


Figure 5. Comparison of MRDA and HITRAN Transmittance Calculations at 500 mb Pressure

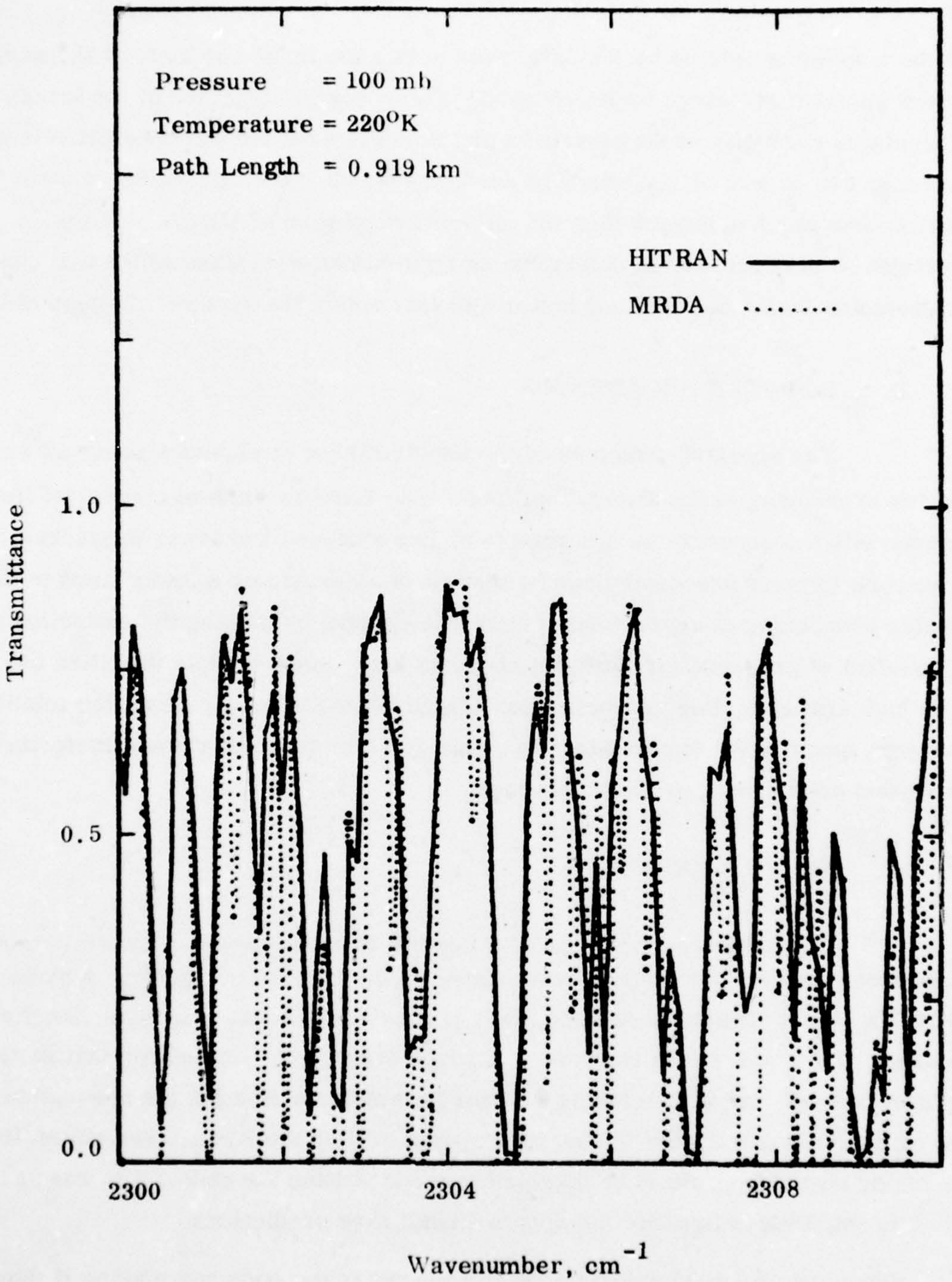


Figure 6. Comparison of MRDA and HITRAN Transmittance Calculations at 100 mb Pressure

that the number of entries on the data tapes not be too large and that, at the same time, the correct spectral structure be reproduced. The spectral structure of the transmittance is calculated correctly at all pressures and temperatures but the absorption is overestimated (by one or two orders of magnitude in some cases) when the full widths of strongly absorbing lines become much narrower than the intended resolution of MRDA, $0.1\ cm^{-1}$. Further investigation is necessary to determine an approximation scheme which will quantitatively parameterize these narrow lines better and stay within the size restrictions of the HP2100.

D. DOPPLER BROADENING

The spectral structure of the transmittance at altitudes above 18 km depends on Doppler broadening of the absorption lines. The Lorentz width of a spectral line decreases linearly with the pressure as one goes to higher altitudes and lower pressures. In this framework Doppler broadening can be thought of as providing a lower limit to the linewidth. Doppler broadening is approximated near line centers by making the extinction coefficient independent of pressure for altitudes above 18 km. Since the gas densities are very low at these high altitudes, this approximation should not significantly affect the total transmittance. However, quantitative verification must wait for a more accurate parameterization of the absorption coefficients on the MRDA tape.

E. RECOMMENDATIONS

The MRDA software code is capable of calculating the transmittance for a range of atmospheric paths. The code is operational on the HP2100 computer. Because of the HP2100's severe limitation on core size, it consists of seven overlays. As the quantitative accuracy of the code needs improvement, it is strongly recommended that further investigation be conducted to determine a better parameterization for the absorption coefficients. The difficulty in getting the MRDA code operational on the HP2100 has necessitated that the major contractual effort be directed towards writing the code. The result is that further effort is required to improve the code's quantitative predictions.

Some specific recommendations for upgrading the code and making it more flexible are listed below.

- Absorption Coefficients: Improve the parameterization of the absorption coefficients for pressures below 600 mb

- Radiation: Incorporate the calculation of atmospheric radiation. Most of the framework and the necessary parameters are already incorporated in the MRDA code
- Model Atmospheres: Increase the user's choice of model atmospheres from the US Standard to include the other five model atmospheres in LOWTRAN3.
- Input: Allow path description to be made through the teletype as well as input files.

APPENDIX A

LISTING OF MRDA

```
PAGE  0001            FTN4 COMPILER: HP24177  (SEPT. 1974)

      FTN,L
      PROGRAM MRDA (3,90)
      DIMENSION NAME(3)
      COMMON TEMP(40),PRES(40),V1,V2,DV,IRAD,LMAX,AHZ2(20)
      COMMON RANGE,WW(40,8)
      COMMON Z(34),P(34),T(34),EH(8,34),WH(34),M,NL,RE,CW,CO,PI
      COMMON WO(34),HZ1(34),HZ2(6),TX(10),VH(8),W(8),E(8)
      COMMON C4(133),C5(15),AHAZE(34),VX(45),C7(45)
      COMMON C7A(45),LYR(40),ALT(40),IPRM
      COMMON X1,X2,H1,H2,N,NP,NP1,NP2,TX1,TX2,YN,YN1,YN2
      COMMON L,JP,L1,L2,PS,TS,X,REF,IP,LBR,EV,TMP,K2,H,DS
      COMMON PSI,SPHI,THET,THETA,PHI,BET,BETA,SALP,SR
      COMMON HMIN,LL,HM,RX,CA,RN,LEN,SUMA,AB,ALAM
      COMMON IXY,VIS,IV1,IV2,IHAZE,ITYPE,ANGLE,FILL(1392)
      COMMON T1,T2,TMIN,P1,P2,PMIN
      DATA NAME/2HSE,2HGT,2H1 /
      IPRM = 1
      CALL EXEC(8,NAME)
      END

**  NO ERRORS**    PROGRAM = 00054       COMMON = 05533
```

```
      PROGRAM SEGT1 (5,90)
      DIMENSION NAME(3)
      COMMON TEMP(40),PRES(40),V1,V2,DV,IRAD,LMAX,AHZ2(20)
      COMMON RANGE,WW(40,8)
      COMMON Z(34),P(34),T(34),EH(8,34),WH(34),M,NL,RE,CW,CO,PI
      COMMON WO(34),HZ1(34),HZ2(6),TX(10),VH(8),W(8),E(8)
      COMMON C4(133),C5(15),AHAZE(34),VX(45),C7(45)
      COMMON C7A(45),LYR(40),ALT(40),IPRM
      COMMON X1,X2,H1,H2,N,NP,NP1,NP2,TX1,TX2,YN,YN1,YN2
      COMMON L,JP,L1,L2,PS,TS,X,REF,IP,LBR,EV,TMP,K2,H,DS
      COMMON PSI,SPHI,THET,THETA,PHI,BET,BETA,SALP,SR
      COMMON HMIN,LL,HM,RX,CA,RN,LEN,SUMA,AB,ALAM
      COMMON IXY,VIS,IV1,IV2,IHAZE,ITYPE,ANGLE,FILL(1391)
      COMMON MM,MODEL,T1,T2,TMIN,P1,P2,PMIN
      INTEGER HZ(2,2)
      DATA NAME/2HSE,2HGT,2H3 /
      DATA HZ(1,1)/2H23/,HZ(1,2)/2HKM/,HZ(2,1)/2H 5/,HZ(2,2)/2HKM/
C***********************************************************************
C     PROGRAM MRDA CALCULATES THE TRANSMITTANCE OF THE ATMOSPHERE
C     FROM 1800 CM-1 TO 6000 CM-1 (1.54 TO 5.56 MICRONS) AT 0.05 CM-1
C     SPECTRAL INTERVALS ON A LINEAR WAVENUMBER SCALE.
C***********************************************************************
C     CALCULATION DEFINED BY FOUR CARD SEQUENCE AT END OF JOB FILE
C
C   CARD 1 MODEL,IHAZE,ITYPE,LEN,JP,IM,NLDAT
C   CARD 2 H1,H2,ANGLE,RANGE,BETA,VIS
C   CARD 3 V1,V2,DV
C   CARD 4 DVM
C
C     MODEL=1 SELECTS U.S. STANDARD MODEL ATMOSPHERE
C     MODEL=0 FOR HORIZ. PATH WHEN METEOROL. DATA USED INSTEAD OF CARD 2
C     READ H1,P(MB),T(DEG C),DEW PT.TEMP(DEG C),%REL HUMIDITY,H2O DENSIT
C     (GM.CM-3), O3 DENSITY(GM.M-3), VIS(KM),RANGE(KM) WITH FORMAT 429.
C     MODEL=2 WHEN NEW MODEL ATMOSPHERE(E.G. RADIOSONDE DATA) USED.
C     DATA CARDS ARE READ IN BETWEEN CARDS 1 AND 2, AND SHOULD CONTAIN
C     ALTITUDE(KM),PRESSURE,TEMP,DEW PT.TEMP,REL. HUMIDITY,H2O DENSITY,
C     O3 DENSITY,AEROSOL NO. DENSITY(CM-3) ACCORDING TO FORMAT 429.
C     NOTE THAT EITHER DEW PT. TEMP. OR REL. HUMIDITY CAN BE USED
C
C     IF IHAZE=0 NO AEROSOL SCATTERING IS COMPUTED
C     IHAZE=1 IF AEROSOL ATTENUATION REQUIRED (THIS IS USED IN
C     CONJUNCTION WITH VISUAL RANGE(SEE CARD 2))
C     IHAZE=1 OR 2 ALSO GIVE AEROSOL ATTENUATION FOR 23 KM AND 5 KM VIS.
C     HAZE MODELS RESPECTIVELY IF VIS=0 ON CARD 2
C
C     ITYPE=1,2 OR 3 INDICATES THE TYPE OF ATMOSPHERIC PATH
C     ITYPE=3, VERTICAL OR SLANT PATH TO SPACE
C     ITYPE=2, VERTICAL OR SLANT PATH BETWEEN TWO ALTITUDES
C     ITYPE=1, CORRESPONDS TO A HORIZONTAL (CONSTANT PRESSURE) PATH
C
C     H1=OBSERVER ALTITUDE (KM)
C     H2=SOURCE ALTITUDE (KM)
C     ANGLE=ZENITH ANGLE AT H1 (DEGREES)
C     RANGE=PATH LENGTH (KM)
C     BETA=EARTH CENTRE ANGLE
C     VIS=VISUAL RANGE AT SEA LEVEL (KM)
```

```
C      (IF ITYPE=1 READ H1 AND RANGE  IF ITYPE=3 READ H1 AND ANGLE.
C      IF ITYPE=2 READ H1 AND TWO OTHER PARAMETERS E.G. H2 AND ANGLE)
C
C      V1=INITIAL FREQUENCY (WAVENUMBER CM-1) INTEGER VALUE
C      V2=FINAL FREQUENCY (WAVENUMBER CM-1) INTEGER VALUE
C      DV=FREQUENCY INTERVALS AT WHICH TRANSMITTANCE IS PRINTED
C      NOTE: DV MUST BE A MULTIPLE OF 5 CM-1
C
C      DVM=MEDIUM RESOLUTION FREQUENCY INTERVAL (USE 0.05 CM-1)
C      IF (IRAD.NE.0) INSERT A CARD FOR EMISSIVITY AND TEMPERATURE
C      OF A BACKGROUND BLACKBODY SOURCE, INSERT AFTER CARD 1.
C      EMISS=ATMOSPHERIC EMISSITIVITY FOR RADIATION CALCULATIONS
C      TBACK=BACKGROUND TEMPERAT.,USED FOR RADIATION CALCULATIONS
C      IRAD =0 ATMOSPHERIC RADIATION NOT CALCULATED
C           =1 ATMOSPHERIC RADIATION CALCULATED
C      ** ONLY RUN PRESENT VERSION WITH IRAD =0 **
C****************************************************************
C
       GO TO(12,2,200,300) IPRM
 12    IPRM = 1
       BET = 0.0
       BETA = 0.0
       IXY = 0
       READ (5,400) IATM,NL
       READ (5,401) (HZ1(L),L=1,34)
       READ (5,401) (HZ2(L),L=1,5)
       DO 1 I=1,NL
 1     READ (5,402) Z(I),P(I),T(I),WH(I),WO(I)
       READ (5,431) (VX(I),C7(I),C7A(I),I=1,44)
       READ (5,405) (C4(I),I=1,133)
       READ(5,404) (C5(I),I=1,15)
       PI=2.0*ASIN(1.0)
       CA=PI/180.
       IP=0
 2     CONTINUE
       RE=6371.23
C      JP NE 0  SUPRESS PRINT
       READ (5,400) MODEL,IHAZE,ITYPE,LEN,JP,IM,NLDAT,IRAD
       WRITE(6,400) MODEL,IHAZE,ITYPE,LEN,JP,IM,NLDAT,IRAD
 200   M=MODEL
       IF(IRAD.EQ.0) GO TO 360
       READ(5,406) EMISS,TBACK
       WRITE(6,351) EMISS,TBACK
 351   FORMAT(//"BACKGROUND SOURCE:  EMISSIVITY=",F5.2,
      15X,"TEMPERATURE="F5.1,"  DEGREES KELVIN"//)
 360   IF(IXY.GT.3) GO TO 8
       IF(M.EQ.2.AND.IM.NE.0) GO TO 4
       IF(M.EQ.0) GO TO 4
 300   READ(5,406) H1,H2,ANGLE,RANGE,BETA,VIS
       WRITE(6,425) H1,H2,ANGLE,RANGE,BETA,VIS
       X1=RE+H1
       IF(ITYPE.EQ.3) GO TO 560
       IF(ITYPE.EQ.1) GO TO 8
       X2=RE+H2
       IF(RANGE.EQ.0) GO TO 5
       WRITE(6,428) H1,H2,ANGLE,RANGE,BETA,VIS
```

```
      IF(H2.EQ.0.AND.ANGLE.NE.0) GO TO 3
      ANGLE=ACOS(0.5*((H2-H1)*(1.+X2/X1)/RANGE-RANGE/X1))/CA
      GO TO 7
3     X2=SQRT((X1/RANGE+RANGE/X1+2.0*COS(ANGLE*CA))*X1*RANGE)
      H2=X2-RE
      GO TO 7
4     CONTINUE
      IF(NLDAT.LE.0)NLDAT=1
      DO 540 L=1,NLDAT
      AHAZE(L)=0.0
      IF(M.EQ.0)READ(5,429)H1,P(1),TMP,DP,RH,WH(L),WO(L),VIS,
     1RANGE
      IF(M.EQ.0)WRITE(6,430)H1,P(1),TMP,DP,RH,WH(L),WO(L),VIS,
     1RANGE
      IF(M.GT.0)READ(5,429)Z(L),P(L),TMP,DP,RH,WH(L),WO(L),
     1AHAZE(L)
      J=IFIX(Z(L)+1.0E-6)+1.
      IF(M.EQ.0)Z(L)=H1
      IF(Z(L).GE.25.0) J=(Z(L)-25.0)/5.0+26.
      IF(Z(L).GE.50.0) J=(Z(L)-50.0)/20.0+31.
      IF(Z(L).GE.70.0) J=(Z(L)-70.0)/30.0+32.
      IF(J.GT.33)J=33
      FAC=Z(L)-FLOAT(J-1)
      IF(J.LT.26) GO TO 500
      FAC=(Z(L)-5.0*FLOAT(J-26)-25.)/5.
      IF(J.GE.31) FAC=(Z(L)-50.0)/20.
      IF(J.GE.32) FAC=(Z(L)-70.0)/30.
      IF(FAC.GT.1.0) FAC=1.0
500   K=J+1
      T(L)=TMP+273.15
      TT=273.15/T(L)
      IF(RH.LE.0.0) TT=273.15/(273.15+DP)
      IF(WH(L).LE.0.0) WH(L)=F(TT)
      IF(RH.GT.0.0) WH(L)=0.01*RH*WH(L)
      IF(Z(L).GE.5.0) GO TO 520
      IF(AHAZE(L).EQ.0.0)AHZ2(L)=HZ2(J)*(HZ2(K)/HZ2(J))**FAC
520   IF(AHAZE(L).EQ.0.0)AHAZE(L)=HZ1(J)*(HZ1(K)/HZ1(J))**FAC
      IF(MODEL.EQ.0) GO TO 8
      IF(L.EQ.1)WRITE(6,441)
      WRITE(6,429)Z(L),P(L),TMP,DP,RH,WH(L),WO(L),AHAZE(L)
540   CONTINUE
      IM=0
      NL=NLDAT
C     NOTE THAT Z(L) MAY NOT CORRESPOND TO THE VALUES GIVEN FOR STANDARD
C     MODEL ATMOSPHERE
      GO TO 300
560   IF(RANGE.GT.0.0) GO TO 580
      IF(H2.GT.0.0.AND.H2.LT.H1) GO TO 16
      GO TO 8
580   ITYPE=2
      BETA=ACOS(0.5*(RANGE*RANGE/(X1*X2)-X2/X1-X1/X2))/CA
5     IF(BETA.EQ.0.) GO TO 6
      GO TO 16
C     BET=CA*BETA
C     X2=RE+H2
C     ANGLE=ATAN(X2*SIN(BET)/(X2*COS(BET)-X1))/CA
```

```
C     RANGE=X2*SIN(BET)/SIN(ANGLE*CA)
C     BET=BETA
C     GO TO 8
6     RANGE=(X2/X1)**2-(SIN(ANGLE*CA))**2
      IF(RANGE.GE.0.0) RANGE=X1*(SQRT(RANGE)-ABS(COS(ANGLE*CA)))
7     IF(ANGLE.NE.0..OR.ANGLE.NE.180.) BET=ASIN(RANGE*SIN(ANGLE*CA)/X2)
      IF(ANGLE.LT.0.) ANGLE=ANGLE+PI
      IF(RANGE.LT.0.0) RANGE=-RANGE
      BET=BET/CA
      WRITE(6,428) H1,H2,ANGLE,RANGE,BET,VIS
8     CONTINUE
      SUMA=0.
      IF(IXY.LE.2) READ(5,406)V1,V2,DV
      IF(IXY.LE.2)WRITE(6,406)V1,V2,DV
      IF(ITYPE.EQ.1) WRITE(6,407) H1,RANGE
      IF(ITYPE.EQ.2) WRITE(6,408) H1,H2,ANGLE
      IF(ITYPE.EQ.3) WRITE(6,409) H1,ANGLE
      IF(MODEL.EQ.0) M=2
      IF(VIS.GT.0.0) WRITE(6,417)VIS
      IF(VIS.LT.2.0.AND.VIS.GT.0.0) WRITE(6,442)
      IF(M.EQ.1) WRITE(6,414) M
      IF(IHAZE.EQ.0) WRITE(6,426)
      IF(VIS.LE.0.0.AND.IHAZE.GT.0) WRITE(6,416)IHAZE,(HZ(IHAZE,L),L
     1=1,2)
      AVW=10000./V1
      ALAM=10000./V2
      WRITE(6,418) V1,V2,DV,ALAM,AVW
      AVW=0.5E-4*(V1+V2)
      AVW=AVW**2
      CO=77.46+.459*AVW
      CW=43.487-0.3473*AVW
9     IF(JP.EQ.0) WRITE(6,427)
      IF(ITYPE.EQ.1) GO TO 15
      DO 11 K=1,8
      VH(K)=0.0
11    CONTINUE
      BETA=0.0
      SR=0.0
      IP=0
C
C***** NOW DEFINE CONSTANT PRESSURE PATH QUANTITES EH(1-4)
C
      Y=CA*ANGLE
      SPHI=SIN(Y)
      R1=(RE+H1)*SPHI
      IF(H1.GT.Z(NL)) GO TO 13
      GO TO 15
13    X=(RE+Z(NL))/(RE+H1)
      IF(SPHI.GT.X) GO TO 14
      H1=Z(NL)
      L1=NL
      SPHI=SPHI/X
      ANGLE=180.0-ASIN(SPHI)/CA
      R1=(RE+H1)*SPHI
      GO TO 15
14    HMIN=R1-RE
```

```
          WRITE(6,433) HMIN
          IPRM=2
          NAME(3) = 2H5
          CALL EXEC(8,NAME)
    15    CONTINUE
          NAME(3) = 2H2
          CALL EXEC(8,NAME)
          CALL MRDA
    16    WRITE(6,445)
          STOP
    400   FORMAT(8I3,F10.3)
    401   FORMAT(8E10.3)
    402   FORMAT(F6.1,E10.3,F6.1,2E10.3)
    404   FORMAT(15F5.2)
    405   FORMAT(8E9.2)
    406   FORMAT(7F10.3)
    407   FORMAT(//,28H HORIZONTAL PATH, ALTITUDE =,F7.3,11H KM,RANGE =,
         1F7.3,3H KM)
    408   FORMAT(//,"SLANT PATH BETWEEN ALTITUDES H1 AND H2 WHERE",/
         1,"H1 =",F7.3,8H KM H2 =,F7.3,18H KM,ZENITH ANGLE =,F7.3,
         28H DEGREES)
    409   FORMAT(//,39HSLANT PATH TO SPACE FROM ALTITUDE H1 =,F7.3,
         1"KM",/,"ZENITH ANGLE =",F7.3,8H DEGREES)
    414   FORMAT(/10X,18H MODEL ATMOSPHERE ,I1,21H = 1962 US STANDARD  )
    416   FORMAT(/10X,18H        HAZE MODEL ,I1,3H = ,2A2,13H VISUAL RANGE)
    417   FORMAT(/25X"HAZE MODEL  =",F5.1," KM VISUAL RANGE AT SEA LEVEL")
    418   FORMAT(/,20HFREQUENCY RANGE V1= ,F7.1,13H CM-1 TO V2= ,F7.1,
         15H CM-1,/,"FOR DV =",F6.1,8H CM-1  (,F6.2," - ",F5.2,"MICRONS)")
    426   FORMAT(/10X,"AEROSOL SCATTERING NOT COMPUTED,IHAZE-0")
    427   FORMAT(///////31X,20H HORIZONTAL PROFILES/)
    428   FORMAT(//"H1=",F7.3,"KM, H2=",F7.3,"KM, ANGLE=",F8.4,", GEOM. R"
         1"ANGE =",F7.2,"KM"/"BETA=",F8.5,"DEG., VIS=",F6.1//)
    429   FORMAT(3F10.3,2F5.1,2E10.3,2F10.3)
    430   FORMAT(10X,"INPUT METEOROLOGICAL DATA:"/," Z=",F7.2," KM, P=",F7
         1.2," MB,T",F5.1," C, DEW PT.TEMP",F5.1," C, REL HUMIDITY=",F5.1,
         2" %"/"  H2O DENSITY=",1PE9.2," GM M-3,OZONE DENSITY=",E9.2," G
         3M-3"/"  VISUAL RANGE=",0PF6.1," KM,RANGE=",F10.3" KM ")
    431   FORMAT(4(F6.2,2F7.5))
    433   FORMAT(//"TRAJECTORY MISSES EARTHS ATMOSPHERE.",/,"CLOSEST DIS"
         1"TANCE OF APPROACH IS",F10.2,1X,/,1X,"END OF CALCULATION")
    441   FORMAT(//"MODEL ATMOSPHERE NO. 2",/ 4X,"Z (KM)",3X,"P (MB)",4X,
         1 "T (C) DEW PT %RH  H2O(GM.M-3) O3(GM.M-3) NO. DEN./")
    442   FORMAT(//"FOG CONDITIONS MAY EXIST AT SEA LEVEL FOR THIS VISUAL RA
         1NGE",/,"  IF SO THEN ASSUME THE TRANSMITTANCE DUE TO FOG IS GIVEN
         2BY"/" THE TRANSMITTANCE AT 0.55 MICRONS")
    425   FORMAT(10X,7F10.3)
    445   FORMAT(//"***ILLEGAL INPUT PARAMETERS FOR MRDA***"/
         1"***CALCULATIONS TERMINATED***")
          END

**  NO ERRORS**    PROGRAM = 02851      COMMON = 05533
```

```
      FTN,L
      PROGRAM SEGT2 (5,90)
      DIMENSION NAME(3)
      COMMON TEMP(40),PRES(40),V1,V2,DV,IRAD,LMAX,AHZ2(20)
      COMMON RANGE,WW(40,8)
      COMMON Z(34),P(34),T(34),EH(8,34),WH(34),M,NL,RE,CW,CO,PI
      COMMON WO(34),HZ1(34),HZ2(6),TX(10),VH(8),W(8),E(8)
      COMMON C4(133),C5(15),AHAZE(34),VX(45),C7(45)
      COMMON C7A(45),LYR(40),ALT(40),IPRM
      COMMON X1,X2,H1,H2,N,NP,NP1,NP2,TX1,TX2,YN,YN1,YN2
      COMMON L,JP,L1,L2,PS,TS,X,REF,IP,LBR,EV,TMP,K2,H,DS
      COMMON PSI,SPHI,THET,THETA,PHI,BET,BETA,SALP,SR
      COMMON HMIN,LL,HM,RX,CA,RN,LEN,SUMA,AB,ALAM
      COMMON IXY,VIS,IV1,IV2,IHAZE,ITYPE,ANGLE,FILL(1391)
      COMMON MM,MODEL,T1,T2,TMIN,P1,P2,PMIN
      DATA NAME/2HSE,2HGT,2H3 /
      GO TO(15,19) IPRM
15    DO 17 L=1,NL
      PS=P(L)/1013.0
      TS=273.15/T(L)
      X=PS*TS
      PT=PS*SQRT(TS)
      D=0.1*WH(L)
      EH(1,L)=0.8*PT*X
      PPW=4.56E-5*D*T(L)
      EH(2,L)=D*PPW*EXP(6.08*(296.0/T(L)-1.0))
      EH(8,L)=D*(PPW+0.12*(PS-PPW))*EXP(4.56*(296.0/T(L)-1.0))
      EH(5,L)=.125E-2*X*WH(L)
      EH(6,L)=.467E-3*X*WO(L)
      EH(3,L)=X
      HAZE=HZ1(L)
      IF(M.EQ.2) HAZE=AHAZE(L)
      IF(Z(L).GE.5.0) GO TO 150
       IF(M.EQ.2.AND.IHAZE.EQ.2) HAZE=HZ2(L)
      IF(IHAZE.EQ.2.AND.M.EQ.2)HAZE=AHZ2(L)
      IF(VIS.LE.0.0) GO TO 150
      IF(M.EQ.2)HAZE= 6.389*((HZ2(L)-HZ1(L))/VIS+HZ1(L)/5.0-HZ2(L)/23.0)
      IF (M.NE.2) GO TO 150
      HAZE=6.389*((AHZ2(L)-AHAZE(L))/VIS+AHAZE(L)/5.0-AHZ2(L)/23.0)
150   IF(HAZE.LT.0.0) HAZE=0.0
      EH(4,L)=3.5336E-4*HAZE
      IF(M.EQ.2) EH(4,L)=HAZE/AHAZE(1)
      EH(7,L)=1.0
      REF=1.0E-6*(CO*X*1013.0/273.15-PPW*CW)
      IF (L.EQ.NL) GO TO 16
      IF(MODEL.EQ.0.AND.L.GE.1) GO TO 26
      T2=T(L+1)
      W2=WH(L+1)
      PPW=4.56E-6*W2*T2
      EH(7,L)=0.5*(REF+1.0E-6*(CO*P(L+1)/T2-PPW*CW))
16    IF (L.EQ.NL) EH(7,L)=0.
      IF (H1.GE.Z(L)) L1=L
      IF(JP.EQ.0) WRITE(6,434) L,Z(L),(EH(K,L),K=1,8),REF
      EH(7,L)=EH(7,L)+1.0
17    CONTINUE
170   IP=-1
```

```
      IK=0
      X1=H1
      CALL POINT (H1,YN,L,NP1,TX,IP)
      T1 = TX(9)
      P1 = TX(10)
      L1=L
      TX1=TX(7)
      DO 18 K=1,8
18    E(K)=TX(K)
      LBR = 0
      IF (ITYPE.EQ.1) GO TO 26
      IF (ITYPE.EQ.3) H2=Z(NL)
      IF (ANGLE.GT.90.0) GO TO 28
19    IF (ANGLE.GT.90.0.AND.NP1.GT.0) L1=L1+1
      L2=NL
      IF (ITYPE.EQ.3) GO TO 20
      CALL POINT (H2,YN,L,NP,TX,IP)
      T2 = TX(9)
      P2 = TX(10)
      L2=L
      IF (NP.GT.0) L2=L2-1
      EH(8,L1)=E(8)
20    DO 21 K=1,6
      EH(K,L1)=E(K)
      IF (ITYPE.EQ.3) GO TO 21
      EH(K,L2+1)=TX(K)
21    CONTINUE
      IF(ITYPE.NE.3)EH(8,L2+1)=TX(8)
      IF (L1.EQ.L2) TX1=TX1+YN-EH(7,L1)
C
C***** NOW DEFINE VERTICAL PATH QUANTITIES VH(1-6)
C
      IF (JP.EQ.0) WRITE(6,420)
      DO 25 L=L1,L2
      X1=Z(L)
      X2=Z(L+1)
      IF (L.EQ.L1) X1=H1
      IF (L.EQ.L2) X2=H2
      DZ=X2-X1
      IF (L.EQ.NL) DZ=Z(L)-Z(L-1)
      DS=DZ
C
C*****  UPWARD TRAJECTORY
C
      RX=(RE+X1)/(RE+X2)
      THETA=ASIN(SPHI)/CA
      PHI=ASIN(SPHI*RX)/CA
      BET=THETA-PHI
      SALP=RX*SPHI
      IF (SPHI.GT.1.E-10) DS=(RE+X2)*SIN(BET*CA)/SPHI
      BETA=BETA+BET
      PSI=BETA+PHI-ANGLE
      PHI=180.-PHI
      SR=SR+DS
      LL = L-L1+LBR+1
      DO 244 K=1,8
```

```
      EV=DS*EH(K,L)
      IF (L.EQ.NL) GO TO 22
      IF (EH(K,L).EQ.0.0.OR.EH(K,L+1).EQ.0.0) GO TO 23
      IF (EH(K,L).EQ.EH(K,L+1)) GO TO 24
      EV=DS*(EH(K,L)-EH(K,L+1))/ALOG(EH(K,L)/EH(K,L+1))
      GO TO 24
22    IF (EH(K,L).EQ.0.0) GO TO 23
      IF (EH(K,L-1).EQ.0.0) GO TO 23
      IF (EH(K,L).EQ.EH(K,L-1)) GO TO 24
      EV=EV/ALOG(EH(K,L-1)/EH(K,L))
      GO TO 24
23    EV=0.
24    VH(K)=VH(K)+EV
C
C***** UPWARD PATH---STORE PARAMETERS
C
244   WW(LL,K) = EV
      LYR(LL) = L
      ALT(LL) = X1
      TEMP(LL) = SQRT(T(L)*T(L+1))
      PRES(LL) = SQRT(P(L)*P(L+1))
      IF (JP.EQ.0) WRITE(6,435) L,X1,(VH(K),K=1,6),BETA,THETA,SR
      IF (L.GE.NL) GO TO 25
      IF (L+1.EQ.L2) EH(7,L+1)=YN
      IF (L.EQ.L1) EH(7,L)=TX1
      RN=EH(7,L+1)/EH(7,L)
      SPHI=SPHI*RX/RN
      IF (SALP.GE.RN) SPHI=SALP
25    CONTINUE
      IPRM = 1
      GO TO 100
26    IPRM = 2
      GO TO 100
28    IPRM = 3
100   NAME(3) = 2H3
      CALL EXEC(8,NAME)
      CALL MRDA
420   FORMAT (///////25X,"VERTICAL PROFILES",/59X,"BETA    THETA"
     13X,"RANGE")
434   FORMAT(I3,F5.1,9(E8.2))
435   FORMAT (I3,F5.1,6E8.2,2F8.3,F6.1)
      END

**  NO ERRORS**    PROGRAM = 01831      COMMON = 05533
```

```
      FTN,L
      PROGRAM SEGT3 (5,90)
      DIMENSION NAME(3)
      COMMON TEMP(40),PRES(40),V1,V2,DV,IRADN,LMAX,AHZ2(20)
      COMMON RANGE,WW(40,8)
      COMMON Z(34),P(34),T(34),EH(8,34),WH(34),M,NL,RE,CW,CO,PI
      COMMON WO(34),HZ1(34),HZ2(6),TX(10),VH(8),W(8),E(8)
      COMMON C4(133),C5(15),AHAZE(34),VX(45),C7(45)
      COMMON C7A(45),LYR(40),ALT(40),IPRM
      COMMON X1,X2,H1,H2,N,NP,NP1,NP2,TX1,TX2,YN,YN1,YN2
      COMMON L,JP,L1,L2,PS,TS,X,REF,IP,LBR,EV,TMP,K2,H,DS
      COMMON PSI,SPHI,THET,THETA,PHI,BET,BETA,SALP,SR
      COMMON HMIN,LL,HM,RX,CA,RN,LEN,SUMA,AB,ALAM
      COMMON IXY,VIS,IV1,IV2,IHAZE,ITYPE,ANGLE,FILL(1391)
      COMMON MM,MODEL,T1,T2,TMIN,P1,P2,PMIN
      DATA NAME /2HSE,2HGT,2H4 /
      GO TO (25,26,28,35) IPRM
25    LBR = L2-L1+LBR+1
      IPRM = 4
      CALL EXEC(8,NAME)
C
C***** HORIZONTAL PATH
C
26    DO 27 K=1,8
      W(K)=RANGE*EH(K,1)
      IF (MODEL.GT.0) W(K)=RANGE*TX(K)
27    WW(1,K) = W(K)
      LYR(1) = L1
      IF(MODEL.EQ.0) TEMP(1) = T(1)
      IF(MODEL.NE.0) TEMP(1) = T1
      IF(MODEL.EQ.0) PRES(1) = P(1)
      IF(MODEL.NE.0) PRES(1) = P1
      IF(MODEL.EQ.0) ALT(1) = Z(1)
      IF(MODEL.NE.0) ALT(1) = H1
      LBR = 1
      GO TO 49
28    CONTINUE
C
C*****  DOWNWARD TRAJECTORY
C
      K2=0
      IF (NP1.EQ.1) L1=L1-1
      L2=L1+1
      YN1=YN
      L0=L1+1
      IF (H2.GT.Z(L1+1).OR.H1.EQ.H2) GO TO 30
      IF (NP1.EQ.1.AND.H2.GE.Z(L1+1)) GO TO 30
      CALL POINT (H2,YN,L,NP2,TX,IP)
      T2 = TX(9)
      P2 = TX(10)
      DO 29 K=1,8
29    W(K)=TX(K)
      TX2=TX(7)
      YN2=YN
      IF (H2.LT.H1) H=H2
      L2=L
```

```
      IF (L1.EQ.L2) TX2=TX1+YN2-EH(7,L)
      IF (H2.GT.H1) TX1=TX2
      IF (L1.EQ.L2.AND.H2.LT.H1) YN1=TX2
30    A0=(RE+H1)*SPHI*YN1
      IF (H2.GE.H1) YN2=YN1
      DO 31 L=1,L1
      HMIN=A0/EH(7,L)-RE
      IF (L.EQ.L1) HMIN=A0/YN1-RE
      LMIN=L
      IF (HMIN.LE.Z(L+1)) GO TO 32
31    CONTINUE
32    X=HMIN
      IF (HMIN.LE.0) GO TO 34
      CALL POINT (X,YN,L,NP,TX,IP)
      TMIN = TX(9)
      PMIN = TX(10)
      LMIN=L
      TX3=TX(7)
      IF (L2.EQ.L.OR.L1.EQ.L) TX3=YN2+TX(7)-EH(7,L)
      IF(TX3.LT.0.0)TX3=TX(7)
      IF (L1.EQ.L.AND.H2.GE.H1) GO TO 33
      HMIN=A0/TX3-RE
      IF (ABS(X-HMIN).GT.0.0001) GO TO 32
33    IF (L1.EQ.L.AND.H2.GE.H1) YN1=TX3
      IF (L2.EQ.L.AND.L1.NE.L2) YN2=TX3
      IF (H2.GE.H1) TX2=TX3
      IF (H2.GE.H1) L2=L
      IF (H2.GE.H1.OR.H2.LT.HMIN) H=HMIN
      WRITE(6,436) HMIN
      IF(H2.LT.HMIN)L2=L
      IF (H2.LT.HMIN) WRITE(6,440) HMIN
      GO TO 35
34    WRITE(6,436) HMIN
      IF (H2.LT.H1) GO TO 35
      IF (ITYPE.EQ.3.OR.H2.GE.H1) WRITE(6,437)
      ITYPE=2
      TX2=EH(7,1)
      LMIN=0
      L2=1
      H2=0.0
      H=0.0
C
C***** NOW DEFINE VERTICAL PATH QUANTITIES VH(1-4)
C
35    IF (JP.EQ.0) WRITE(6,420)
      L = L0
      LL = LBR
      DO 40 I=1,NL
      LL = LL+1
      L=L-1
      REF=EH(7,L)
      IF (I.EQ.1) REF=YN1
      IF (I.EQ.1.AND.K2.EQ.1) REF=YN2
      IF (L.EQ.L2.AND.K2.EQ.0) REF=TX2
      IF (I.NE.1) X1=Z(L+1)
      X2=Z(L)
```

```
      IF (L.EQ.L2.AND.K2.EQ.0) X2=H
      IF (L.EQ.LMIN.AND.K2.EQ.1) X2=HMIN
      HM=(RE+X1)*SPHI-RE
      IF (HM.GT.Z(L).AND.HM.GT.X2) X2=HM
      RX=(RE+X1)/(RE+X2)
      DS=X1-X2
      ALP=90.0
      THET=ASIN(SPHI)/CA
      SALP=RX*SPHI
      IF (ABS(X2-HM).GT.1.0E-5) ALP=ASIN(SALP)/CA
      BET=ALP-THET
      IF (SPHI.GT.1.0E-10) DS=(RE+X2)*SIN(BET*CA)/SPHI
      THETA=180.0-THET
      BETA=BETA+BET
      PSI=BETA-ALP-ANGLE+180.0
      SR=SR+DS
      DO 399 K=1,8
      AL=EH(K,L)
      BL=EH(K,L+1)
      IF (L.EQ.L1) BL=E(K)
      IF (L.EQ.L2.AND.H2.LT.H1.AND.H2.GT.0.0) AL=W(K)
      IF (L.EQ.LMIN.AND.H2.GE.H1) AL=TX(K)
      IF (L.EQ.LMIN.AND.ABS(H2-HM).LT.1.0E-5) AL=TX(K)
      IF (K2.EQ.0) GO TO 36
      IF (L.EQ.L2) BL=W(K)
      IF (L.EQ.LMIN) AL=TX(K)
36    IF (AL.EQ.0.0.OR.BL.EQ.0.0) GO TO 38
      IF (AL.EQ.BL) GO TO 37
      EV=DS*(AL-BL)/ALOG(AL/BL)
      GO TO 39
37    EV=DS*AL
      GO TO 39
38    EV=0.0
39    VH(K)=VH(K)+EV
C
C***** DOWNWARD PATH---STORE PARAMETERS
C
399   WW(LL,K) = EV
      LBR = LL
      LYR(LL) = L
      ALT(LL) = X1
      TEMP(LL) = SQRT(T(L)*T(L+1))
      PRES(LL) = SQRT(P(L)*P(L+1))
      IF (JP.EQ.0) WRITE(6,435) L,X1,(VH(K),K=1,6),BETA,THETA,SR
      IF (L.EQ.L2.AND.H2.GE.H1) GO TO 45
      IF (L.EQ.LMIN.AND.K2.EQ.1) GO TO 43
      IF (L.NE.1) RN=REF/EH(7,L-1)
      IF (L.EQ.L2+1) RN=REF/TX2
      IF (L.EQ.L2.AND.K2.EQ.0) RN=REF/YN2
      IF (L.EQ.(LMIN+1).AND.K2.EQ.1) RN=REF/TX3
      IF (SALP.GE.RN) RN=1.0
      SPHI=SALP*RN
      IF (L.EQ.L2.AND.K2.EQ.0) GO TO 41
40    CONTINUE
41    IPRM = 1
      TEMP(LL) = SQRT(T2*T(L))
```

```
      PRES(LL) = SQRT(P2*P(L))
      GO TO 100
43    IPRM = 2
      TEMP(LL) = SQRT(TMIN*T(L+1))
      PRES(LL) = SQRT(PMIN*P(L+1))
      GO TO 100
45    IPRM = 3
      TEMP(LL) = SQRT(T1*T(L))
      PRES(LL) = SQRT(P2*P(L))
      GO TO 100
49    IPRM = 5
100   CALL EXEC(8, NAME)
      CALL MRDA
420   FORMAT (///////25X,"VERTICAL PROFILES",/59X,"BETA   THETA"
     13X,"RANGE")
435   FORMAT (I3,F5.1,6E8.2,2F8.3,F6.1)
436   FORMAT (//"HMIN = ",F10.3)
437   FORMAT (//"PATH INTERSECTS EARTH - PATH CHANGED TO TYPE 2 WITH H"
     1"2 = 0.0 KM")
440   FORMAT (//"H2 WAS SET LESS THAN HMIN AND HAS BEEN RESET"/"EQUAL "
     1"TO HMIN I.E. H2 = ",F10.3)
      END
```

** NO ERRORS** PROGRAM = 01863 COMMON = 05533

```
      FTN,L
      PROGRAM SEGT4 (5,90)
      DIMENSION NAME(3)
      COMMON TEMP(40),PRES(40),V1,V2,DV,IRAD,LMAX,AHZ2(20)
      COMMON RANGE,WW(40,8)
      COMMON Z(34),P(34),T(34),EH(8,34),WH(34),M,NL,RE,CW,CO,PI
      COMMON WO(34),HZ1(34),HZ2(6),TX(10),VH(8),W(8),E(8)
      COMMON C4(133),C5(15),AHAZE(34),VX(45),C7(45)
      COMMON C7A(45),LYR(40),ALT(40),IPRM
      COMMON X1,X2,H1,H2,N,NP,NP1,NP2,TX1,TX2,YN,YN1,YN2
      COMMON L,JP,L1,L2,PS,TS,X,REF,IP,LBR,EV,TMP,K2,H,DS
      COMMON PSI,SPHI,THET,THETA,PHI,BET,BETA,SALP,SR
      COMMON HMIN,LL,HM,RX,CA,RN,LEN,SUMA,AB,ALAM
      COMMON IXY,VIS,IV1,IV2,IHAZE,ITYPE,ANGLE,FILL(1392)
      COMMON T1,T2,TMIN,P1,P2,PMIN
      DATA NAME /2HSE,2HGT,2H5 /
      GO TO (41,43,45,47,49) IPRM
41    IF (HMIN.LE.0) GO TO 47
      IF (LEN.EQ.0) WRITE(6,438)
      IF (LEN.EQ.0) GO TO 47
      IF (LEN.EQ.1) WRITE(6,439)
      K2=1
      X1=X2
      IF (ABS(X1-HMIN).LE.0.001) GO TO 47
      H=HMIN
      L=L2+1
      IF (NP2.EQ.1) L=L-1
      B=BETA
      PH=180.0-ASIN(SPHI)/CA
      TS=SR
      PS=PSI
      DO 42 K=1,8
42    E(K)=VH(K)
      LSTORE = LBR
      GO TO 35
43    BETA=2.*BETA-B
      PSI=2.*PSI-PS
      SR=2.*SR-TS
C      LONG PATH  TAKEN
      PHI=PH
      DO 44 K=1,8
44    VH(K)=2.*VH(K)-E(K)
C
C***** DOWNWARD H2.GT.H1--LONG PATH STORAGE
C
      LLMIN = LBR+1
      LBR = 2*LBR-LSTORE
      DO 446 LL=LLMIN,LBR
      LMAP = LBR - LL + LSTORE
      ALT(LL) = ALT(LMAP+2)
      IF(LL.EQ.LLMIN) GO TO 442
      TEMP(LL) = SQRT(T(LMAP+1)*T(LMAP+2))
      PRES(LL) = SQRT(P(LMAP+1)*P(LMAP+2))
      GO TO 444
442   ALT(LL) = HMIN
      PRES(LL) = SQRT(PMIN*P(LMAP+2))
```

```
              TEMP(LL) = SQRT(TMIN*T(LMAP+2))
      444     CONTINUE
              DO 446 K=1,6
      446     WW(LL,K) = WW(LMAP+1,K)
              GO TO 47
      45      DO 46 K=1,8
      46      VH(K)=2.0*VH(K)
      C
      C***** DOWNWARD H1.LT.H2---H1.NE.HMIN
      C
              LLMIN = LBR+1
              LBR = 2*LBR
              DO 468 LL=LLMIN,LBR
              LMAP = LBR-LL
              ALT(LL) = ALT(LMAP+2)
              IF(LL.EQ.LLMIN) GO TO 464
              TEMP(LL) = SQRT(T(LMAP+1)*T(LMAP+2))
              PRES(LL) = SQRT(P(LMAP+1)*P(LMAP+2))
              GO TO 466
      464     ALT(LL) = HMIN
              TEMP(LL) = SQRT(TMIN*T(LMAP+2))
              PRES(LL) = SQRT(PMIN*P(LMAP+2))
      466     LYR(LL) = LYR(LMAP+1)
              DO 468 K=1,6
      468     WW(LL,K) = WW(LMAP+1,K)
              BETA=2.0*BETA
              SR=2.0*SR
              IF (H2.EQ.H1) GO TO 47
              RN=TX1/YN1
              SPHI=SIN(ANGLE*CA)
              IF (SPHI.LT.RN) SPHI=SPHI/RN
              GO TO 19
      47      CONTINUE
              WRITE(6,406) HM
              DO 48 K=1,8
              W(K)=VH(K)
      48      CONTINUE
      49      WRITE (6,419)
              WRITE(6,421) (W(K),K=1,4),W(8)
              I=1
              L=1
              IV1=V1/5.0
              IF(V2.GT.32767.) V2=32767.
              IV2=V2/5.+.998
              IV1=5*IV1
              IV2=5*IV2
              IF (IV1.LT.350) IV1=350
              IF (DV.LT.5.) DV=5.
              NAME(3) = 2H5
              GO TO 100
      35      IPRM = 4
              NAME(3) = 2H3
              GO TO 100
      19      IPRM = 2
              NAME(3) = 2H2
      100     CALL EXEC(8,NAME)
```

```
            CALL MRDA
      406   FORMAT(7F10.3)
      419   FORMAT (/16X,38H EQUILAVENT SEA LEVEL ABSORBER AMOUNTS//
           17X"   NITROGEN (CONT)  H2O (CONT)     MOL  SCAT      AEROSOL,"/
           27X"           KM            GM CM-2          KM                KM"/)
      421   FORMAT (8H W(1-4)=4(E14.3)/ 22X,E14.3/)
      438   FORMAT(//"CHOICE OF TWO PATHS FOR THIS CASE -SHORTEST PATH TAKE"
           1"N."/"FOR LONGER PATH SET LEN=1.")
      439   FORMAT(///1X,"LL",3X,"LEVEL",2X,"ALTITUDE   TEMP",6X,"PRES",
           17X,"WH2O",7X,"WO3",8X"WGAS"/)
      500   FORMAT(/"DISK I/O ERROR, IERR =",I3)
            END

** NO ERRORS**    PROGRAM = 01066      COMMON = 05533
```

```
      FTN,L
      PROGRAM SEGT5 (5,90)
      DIMENSION TRAN1(41),IDCB(144),ISIZE(2),NAM1(3)
      DIMENSION NAME(3),TAU(21),WH2O(40),WO3(40),WGAS(40)
      COMMON TEMP(40),PRES(40),V1,V2,DV,IRAD,LMAX,AHZ2(20)
      COMMON RANGE,WW(40,8)
      COMMON Z(34),P(34),T(34),EH(8,34),WH(34),M,NL,RE,CW,CO,PI
      COMMON WO(34),HZ1(34),HZ2(6),TX(10),VH(8),W(8),E(8)
      COMMON C4(133),C5(15),AHAZE(34),VX(45),C7(45)
      COMMON C7A(45),LYR(40),ALT(40),IPRM
      COMMON X1,X2,H1,H2,N,NP,NP1,NP2,TX1,TX2,YN,YN1,YN2
      COMMON L,JP,L1,L2,PS,TS,X,REF,IP,LBR,EV,TMP,K2,H,DS
      COMMON PSI,SPHI,THET,THETA,PHI,BET,BETA,SALP,SR
      COMMON HMIN,LL,HM,RX,CA,RN,LEN,SUMA,AB,ALAM
      COMMON IXY,VIS,IV1,IV2,IHAZE,ITYPE,ANGLE,FILL(1392)
      COMMON T1,T2,TMIN,P1,P2,PMIN
      EQUIVALENCE (TAU,AHZ2),(WH2O,WW(1,1)),(WO3,WW(1,2))
      EQUIVALENCE (WGAS,WW(1,3))
      DATA NAME /2HSE,2HGT,2H5 /,NAM1/2HTR,2HAN,2H1  /
C
C***** BEGINNING OF TRANSMITTANCE CALCULATIONS
C
      ISIZE(1) = 150
      IF(IRAD.NE.0) CALL CREAT(IDCB,IERR,NAM1,ISIZE,3)
      IF(IERR.EQ.-1) GO TO 110
      IDV = DV
      IV = IV1-IDV
      LMAX = LBR
      LOOP = 1
      INDEX = 0
      IF(IRAD.EQ.1) LOOP = LBR
50    IV = IV+IDV
      INDEX=INDEX+1
      IF(INDEX.NE.1) GO TO 52
      IF(JP.NE.0) GO TO 52
      WRITE(6,422)
52    CONTINUE
      DO 95 LL=1,LOOP
      DO 53 K=1,8
      W(K) = VH(K)
      IF(LL.GT.1) W(K) = W(K)-WW(LL-1,K)
      TX(K) = 0.0
53    CONTINUE
      TX(1) = 1.0
      ICOUNT=ICOUNT+1
      SUM=0.0
      V=IV
      I=(IV-350)/5+1
      IF(IV.LT.670) GO TO 72
      IF(IV.LE.3000) GO TO 61
C
C*****   MOLECULAR SCATTERING
C
      C6=9.807E-20*(V**4.0117)
      TX(3)=C6*W(3)
      SUM=SUM+TX(3)
```

```
      IF (IV.LT.13000) GO TO 72
C
C*****  WATER VAPOR CONTINUUM 10 MICRON REGION
C
   61 IF(IV.GT.1350) GO TO 62
      TX(2)=(4.18+5578.0*EXP(-7.87E-3*V))*W(2)
      GO TO 66
   62 IF(IV.LT.2350) GO TO 68
C
C*****  WATER VAPOR CONTINUUM 4 MICRON REGION
C
      XI=(V-2350.0)/50.0+1.0
      DO 63 NH=1,15
      XH=XI-FLOAT(NH)
      TX(2)=C5(NH)
      IF(XH) 64,65,63
   63 CONTINUE
  64  TX(2)=TX(2)+XH*(C5(NH)-C5(NH-1))
   65 TX(2)=TX(2)*W(8)
   66 SUM=SUM+TX(2)
      IF(IV.LE.1350.OR.IV.GT.2740) GO TO 72
C
C*****   NITROGEN CONTINUUM
C
68    IF (IV.LT.2080) GO TO 72
      K4=I-346
      TX(1)=C4(K4)*W(1)
      SUM=SUM+TX(1)
C
C*****   AEROSOL EXTINCTION
C
72    ALAM=1.0E+4/V
      XX=0.0
      YY=0.0
      IF (IHAZE.EQ.0.) GO TO 90
      DO 88 N=1,44
      XD=ALAM-VX(N)
      IF(XD)89,88,88
   88 CONTINUE
   89 XX=(C7(N)-C7(N-1))*XD/(VX(N)-VX(N-1))+C7(N)
      YY=(C7A(N)-C7A(N-1))*XD/(VX(N)-VX(N-1))+C7A(N)
    90 TX(8)=YY*W(4)
      TX(4)=XX*W(4)
      SUM=SUM+TX(4)
      TX(7)=SUM
      DO 94 K=1,8
      IF (TX(K).EQ.0.0) GO TO 92
      IF (TX(K).GT.20.) GO TO 93
      TX(K)=EXP(-TX(K))
      GO TO 94
92    TX(K)=1.0
      GO TO 94
93    TX(K)=0.
94    CONTINUE
      TX(8)=1.0-TX(8)
      AB=1.-TX(7)
```

```
PAGE  0003  SEGT5   FTN4 COMPILER: HP24177  (SEPT. 1974)

      IF(IV.EQ.IV1.OR.IV.EQ.IV2) AB=0.5*AB
      SUMA=SUMA+AB*DV
      IF(JP.EQ.0.AND.LL.EQ.1) WRITE(6,423) IV,ALAM,TX(7),(TX(K),
     1K=1,4),TX(8),SUMA
      IF(IRAD.NE.0) TRAN1(LL)=TX(7)
95    CONTINUE
      TAU(INDEX) = TX(7)
      TRAN1(LMAX+1) = IV
      IL = (LMAX+1)*2
      IF(IRAD.NE.0) CALL WRITF(IDCB,IERR,TRAN1,IL)
      IF(IERR.EQ.-1) GO TO 110
      IF(IV.GE.IV2) GO TO 96
      GO TO 50
96    WRITE(6,496)
      DO 97 LL=1,LMAX
      FAC = WW(LL,3)
      WH2O(LL) = WW(LL,5)/FAC
      WO3(LL) = WW(LL,6)/FAC
      WGAS(LL) = FAC
C
C***** TEMPORARY PRINT OUT
C
97    WRITE(6,498) LL,LYR(LL),ALT(LL),TEMP(LL),PRES(LL),WH2O(LL)
     1,WO3(LL),WGAS(LL)
      IPRM = 1
      NAME(3) = 2H6
      IF(IRAD.EQ.0) GO TO 102
      IF(WRITF(IDCB,IERR,IBUF,-1)) 110,101,101
101   IF(CLOSE(IDCB,IERR)) 110,102,102
102   CALL EXEC(8,NAME)
      CALL MRDA
110   WRITE(6,500) IERR
      STOP
422   FORMAT (/////"  FREQ WAVELENGTH  TOTAL  "
     1" N2 CONT  H2O CONT MOL SCAT AEROSOL AEROSOL INTEGRATED"
     2/1X,14H CM-1  MICRONS,4(4X5HTRANS),4X,"TRANS    ABS   ABSORP"
     3"TION"/)
423   FORMAT (I6,7F9.4,F10.2)
496   FORMAT(///1X,"LL",3X,"LEVEL",2X,"ALTITUDE",3X,"TEMP",6X,"PRES",
     17X,"WH2O",7X,"WO3",8X,"WGAS"/)
498   FORMAT(I3,I6,3F10.2,2X,3E11.3)
500   FORMAT(/"DISK I/O ERROR, IERR =",I3)
      END

**  NO ERRORS**    PROGRAM = 01602       COMMON = 05533
```

```
      FTN,L
      PROGRAM SEGT6 (5,90)
      DIMENSION IDCB(144),JDCB(144),ISIZE(2),NAM1(3),NAM2(3)
      DIMENSION NUM(6),KPTS(3,40),CON(6),SPEC(6,2),Z(2)
      DIMENSION NAME(3),PP(9),TT(9),TRAN1(41),TRAN2(41)
      DIMENSION BUF(63)
      COMMON TEMP(40),PRES(40),V1,V2,DV,IRAD,LMAX,TAU(21)
      COMMON WH2O(40),WO3(40),WGAS(40),VV(250),AK(9,250)
      INTEGER SPEC
      DATA CON /0.0,.330E-3,0.0,75E-7,1.6E-6/
      DATA NAME /2HSE,2HGT,2H7 /,NAM1/2HTR,2HAN,2H1 /
      DATA NAM2 /2HTR,2HAN,2H2 /
C
C***** READ CONTINUUM TAU'S FOR RADIATION CALC
C
      IOPTN = 0
      IF(IRAD.EQ.0) GO TO 70
      IF(OPEN(IDCB,IERR,NAM1,IOPTN)) 500,60,60
60    IF(READF(IDCB,IERR,TRAN1)) 500,61,61
61    IF(READF(IDCB,IERR,TRAN2)) 500,62,62
62    RV1 = TRAN1(LMAX+1)
      RV2 = TRAN2(LMAX+1)
70    CONTINUE
      IB = 1
      ISIZE(1) = 50
      IF(CREAT(JDCB,IERR,NAM2,ISIZE,3)) 500,95,95
C
C***** INSURE THAT (V1,V2) ARE WITHIN TAPES RANGE
C
95    READ(5,900) DVM
      IF(DVM.LT.0.005) DVM=0.005
      WRITE(6,938) DVM
      MSPEC = 6
C
C***** READ TAPE BLOCK INTO DISK FILE
C
      REWIND 8
      READ(8,900) VMIN,VMAX,NPT
      IF(V2.GT.VMIN) GO TO 105
100   WRITE(6,942) V1,V2,VMIN,VMAX
      STOP
105   IF(V1.GE.VMAX) GO TO 100
120   IF(V1.GE.VMIN) GO TO 122
      WRITE(6,930) V1,VMIN
      V1 = VMIN
122   IF(V2.LE.VMAX) GO TO 123
      WRITE(6,931) V2,VMAX
      V2 = VMAX
123   CONTINUE
C
C***** READ P,T VALUES FROM DISK FILE
C
      READ(8,901)(PP(K),K=1,NPT)
      READ(8,901)(TT(K),K=1,NPT)
C
C***** DETERMINE INTERPOLATION POINTS FOR EACH LAYER
```

```
C
      CALL PTPTS(PP,TT,LMAX,KPTS)
C
C***** READ IN WAVENUMBER BLOCKS
C
      VCHK1 = V1-10.
      VCHK2 = V2+10.
      ILP = 1
125   NUM1 = 1
      READ(8,900) VA,VB
      DO 128 M=1,MSPEC
      READ(8,902) SPEC(M,1),SPEC(M,2),NUM2
      NUM(M) = NUM1
      NUM1 = NUM1+NUM2
      NMIN = NUM(M)
      NMAX = NUM1-1
      IF(NMAX.GT.250) WRITE(6,933) VA,NMAX,M
      DO 127 N=NMIN,NMAX
127   READ(8,903) VV(N),(AK(K,N),K=1,NPT)
128   CONTINUE
      IF(VA.GT.VCHK1) GO TO 129
      WRITE(6,933) VA,(NUM(N),N=1,6),NMAX
      GO TO 125
129   IF(VA.GE.VCHK2) GO TO 160
C
C***** CALCULATE TRANSMISSION
C
      WRITE(6,906) NUM(1),NUM(6)
      IF(ILP.EQ.1) WRITE(6,932)
      ILP = ILP+1
      V = VV(NMIN)
      V0 = V
      N = 0
135   IF(V.GE.V1) GO TO 136
      N = N+1
      V = V0 + FLOAT(N)*DVM
      GO TO 135
136   N = 0
      V0 = V
140   N = N+1
      RAD = 0.0
      RAD1 = 1.0
      FAC1 = 0.0
C***** CONTINUUM TAU'S FOR RADIANCE CALC
      IF(IRAD.EQ.0) GO TO 1404
1401  IF(RV2.GE.V) GO TO 1404
      DO 1402 LL=1,LMAX
1402  TRAN1(LL) = TRAN2(LL)
      RV1 = RV2
      IF(READF(IDCB,IERR,TRAN2)) 500,1403,1403
1403  RV2 = TRAN2(LMAX+1)
      GO TO 1401
1404  CONTINUE
      DO 150 LL=1,LMAX
      DIST = WGAS(LL)
      CON(1) = WH2O(LL)
```

```
      CON(3) = WO3(LL)
      FAC2 = 0.0
      PBAR = PRES(LL)
      IF(PBAR.LT.75.) PBAR=75.
      DO 142 M=1,MSPEC
      IF(AK(1,NUM(M)).EQ.0.0) GO TO 142
      M1 = NUM(M)
1405  VV1 = VV(M1)
      VV2 = VV(M1+1)
      IF(V.LE.VV2) GO TO 1406
      M1 = M1 + 1
      GO TO 1405
1406  CONTINUE
141   DO 1411 I=1,2
      N1 = M1+I-1
      Y0 = AK(KPTS(2,LL),N1)
      FT = F1(Y0,AK(KPTS(1,LL),N1),TT(KPTS(2,LL)),TT(KPTS(1,LL))
     1,TEMP(LL))
      FP = F1(Y0,AK(KPTS(3,LL),N1),PP(KPTS(2,LL)),PP(KPTS(3,LL))
     1,PBAR)
      AKK = FT+FP-Y0
      IF(AKK.LT.0) AKK=0
      IF(PBAR.LT.75.1)AKK=AKK*TEMP(LL)/216.6
      IF(VV(N1).EQ.V) GO TO 1412
      Z(I) = AKK
1411  CONTINUE
      AKK = F1(Z(1),Z(2),VV1,VV2,V)
1412  FAC2 = FAC2 + AKK*CON(M)*DIST
142   CONTINUE
      FAC2 = FAC2*1.0E5
      IF(IRAD.EQ.0) GO TO 149
      TRN = 0.0
      IF(FAC2.LT.20.) TRN = EXP(-FAC2)
      PLANK = BLAM(TEMP(J),V)
      RAD = TRN*RAD+(1.0-TRN)*PLANK
      FAC4 = F1(TRAN1(LL),TRAN2(LL),RV1,RV2,V)
      FAC5 = 1.0
      IF(LL.NE.LMAX) FAC5 = F1(TRAN1(LL+1),TRAN2(LL+1),RV1,RV2,V)
      RAD1 = RAD1 + (FAC5-FAC4)*PLANK
149   FAC1 = FAC1+FAC2
150   CONTINUE
      RAD = RAD+RAD1
      TRAN = 0.0
      IF(FAC1.LT.20.) TRAN = EXP(-FAC1)
      BUF(IB) = V
      BUF(IB+1) = TRAN
      BUF(IB+2) = RAD
      IB = IB+3
      IL = (IB-1)*2
      IF(IB.NE.64) GO TO 155
      IB = 1
      IF(WRITF(JDCB,IERR,BUF,IL)) 500,155,155
155   WRITE(6,934) V,TRAN,RAD
      V = V0 + FLOAT(N)*DVM
      IF(V.GT.V2) GO TO 160
      IF(V.LE.VB) GO TO 140
```

```
            N = N-1
            GO TO 125
      160   IF(WRITF(JDCB,IERR,BUF,IL)) 500,165,165
      165   IF(WRITF(JDCB,IERR,BUF,-1)) 500,170,170
      170   IF(IRAD.EQ.1) IF(PURGE(IDCB,IERR,NAM2)) 500,175,175
      175   IF(CLOSE(JDCB,IERR)) 500,180,180
      180   CALL EXEC(8,NAME)
            CALL MRDA
      500   WRITE(6,940) IERR
            STOP
      900   FORMAT(2F10.2,I5)
      901   FORMAT(9F10.2)
      902   FORMAT(2A2,I5)
      903   FORMAT(F12.2,9E12.6)
      906   FORMAT("NMIN,NMAX=",2I10)
      930   FORMAT(//"V1 =",F10.2,5X,"TOO SMALL, RESET TO",F10.2," CM-1")
      931   FORMAT(//"V2 =",F10.2,5X,"TOO LARGE, RESET TO",F10.2," CM-1")
      932   FORMAT(//"    FREQ        TRAN      RAD",/)
      933   FORMAT("BLOCK SKIPPED, V =",F5.1," WAVENUMBERS",7I6)
      934   FORMAT(F10.2,F10.4,2E10.3)
      936   FORMAT(2I10)
      938   FORMAT(/"MEDIUM RESOLUTION DV =",F5.1," WAVENUMBERS"/)
      940   FORMAT(//"DISK I/O ERROR, IERR =",I3)
      942   FORMAT("TAPE OUT OF RANGE OF DATA"/"V1 =",F7.1,", V2 ="
           1,F7.1,", VMIN =",F7.1,", VMAX =",F7.1)
            END

**  NO ERRORS**     PROGRAM = 02397       COMMON = 05450
```

```
PAGE  0001          FTN4 COMPILER: HP24177  (SEPT. 1974)

      FUNCTION BLAM(T,V)
      BLAM = 1.1989E-16*V**5/EXP(1.4338*V/T-1.)
      RETURN
      END

**  NO ERRORS**    PROGRAM = 00050      COMMON = 00000
```

```
PAGE  0001          FTN4 COMPILER: HP24177  (SEPT. 1974)

      FUNCTION F1(Y1,Y2,X1,X2,X)
      F1 = Y1+(Y2-Y1)*(X-X1)/(X2-X1)
      RETURN
      END
```

```
      FTN,L
      PROGRAM SEGT7 (5,90)
      COMMON TEMP(40),PRES(40),V1,V2,DV,IRAD,LMAX,TAU(21)
      COMMON WH2O(40),WO3(40),WGAS(40),VV(250),AK(9,250)
      DIMENSION V(1001),NAM2(3)
      DIMENSION JDCB(144),BUF(63),TR(2,1050)
      EQUIVALENCE (WH2O,TR(1,1))
      DATA NAM2/2HTR,2HAN,2H2 /
      IK = 1
      NUMV = 0
      IOPTN = 0
      IF(OPEN(JDCB,IERR,NAM2,IOPTN)) 100,10,10
10    IF(READF(JDCB,IERR,BUF,128,LEN)) 100,11,11
11    IF(LEN.EQ.-1) GO TO 20
      LEN = LEN/6
      NUMV = NUMV+LEN
      DO 15 I=1,LEN
      V(IK) = BUF(I*3-2)
      TR(1,IK) = BUF(I*3-1)
      TR(2,IK) = BUF(I*3)
      IK = IK+1
15    CONTINUE
      GO TO 10
C
C***** FOLD IN CONTINUUM RESULTS
C
20    IF(RWNDF(JDCB,IERR)) 100,21,21
21    IMAX = I-1
      DO 25 I=1,NUMV
      CALL CALC2(V(I),T)
25    TR(1,I) = T*TR(1,I)
      IF(IRAD.EQ.0) TR(2,I) = 0.0
      WRITE(6,902)
      II=0
      DO 70 I=1,NUMV
      II=II+1
      WRITE(6,903) V(I),TR(1,I),TR(2,I)
      BUF(II*3-2) = V(I)
      BUF(II*3-1) = TR(1,I)
      BUF(II*3) = TR(2,I)
      IF(II.NE.21) GO TO 70
      IL = 126
      IF(WRITF(JDCB,IERR,BUF,IL)) 100,55,55
55    II=0
70    CONTINUE
      IL = II*6
      IF(WRITF(JDCB,IERR,BUF,IL)) 100,80,80
80    STOP
100   WRITE(6,904) IERR
      GO TO 80
902   FORMAT(//"  V      TRANS    RAD"/)
903   FORMAT(F6.1,2F8.4)
904   FORMAT(//"DISK I/0 ERROR, IERR =",I3)
      END
```

```
      FTN,L
      SUBROUTINE POINT (X,YN,N,NP,TX,IP)
      COMMON TEMP(40),PRES(40),V1,V2,DV,IRAD,LMAX,AHZ2(20)
      COMMON RANGE,WW(40,8)
      COMMON Z(34),P(34),T(34),EH(8,34),WH(34),M,NL,RE,CW,CO,PI
      DIMENSION TX(10)
C*********************************************************************
C     SUBROUTINE POINT COMPUTES THE MEAN REFRATIVE INDEX ABOVE AND BELOW
C     A GIVEN ALTITUDE AND INTERPOLATES EXPONENTIALLY TO DETERMINE THE
C     EQUIVALENT ABSORBER AMOUNTS AT THAT ALTITUDE.
C
C*********************************************************************
C
C      X IS THE HEIGHT IN QUESTION
C      TX(7) AND YN ARE THE MEAN REFRACTIVE INDICES ABOVE AND BELOW X
C      N IS THE LEVEL INTEGER CORRESPONDING TO X OR THE LEVEL BELOW X
C      NP =1 IF X COINCIDES WITH MODEL ATMOSPHERE LEVEL ,IF NOT NP = 0
C      TX(1-6) ARE ABSORBER  AMOUNTS PER KM AT HEIGHT X
C*********************************************************************
      N=NL
      NP=0
      IF (X.LT.0.0) X=0.
      IF (X.GT.Z(NL)) GO TO 4
      DO 1 I=1,NL
      N=I
      IF (X-Z(I)) 2,4,1
1     CONTINUE
2     J2=N
      N=N-1
      FAC=(X-Z(N))/(Z(J2)-Z(N))
      PX1=P(N)*(P(J2)/P(N))**FAC
      TX1=T(N)*(T(J2)/T(N))**FAC
      TX(9) = TX1
      TX(10)= PX1
      WX1=WH(N)*(WH(J2)/WH(N))**FAC
      TX(3) = CO*PX1/TX1-4.56E-6*WX1*TX1*CW
      TX(2) = CO*P(J2)/T(J2)-4.56E-6*WH(J2)*T(J2)*CW
      TX(1) = CO*P(N)/T(N)-4.56E-6*WH(N)*T(N)*CW
      TX(7) = 0.5E-6*(TX(2)+TX(3))
      YN = 0.5E-6*(TX(1)+TX(3))
      IF (IP.EQ.0) GO TO 9
      DO 3 L=1,7
      K=L
      IF(L.EQ.7) K=8
      IF (EH(K,N).EQ.0.0) GO TO 3
      IF (EH(K,N).GT.1000.0) GO TO 3
      TX(K)=EH(K,N)*(EH(K,J2)/EH(K,N))**FAC
3     CONTINUE
      GO TO 9
4     NP=1
      IF (IP.EQ.0) GO TO 6
      DO 5 K=1,8
5     TX(K)=EH(K,N)
6     TX(7)=EH(7,N)-1.
      YN=0.0
      IF (N.GT.1) YN=EH(7,N-1)-1.0
```

```
9     CONTINUE
      IF (IP.EQ.1)WRITE(6,400) X,N,NP,TX(7),YN,IP,(TX(K),K=1,4)
      TX(7)=TX(7)+1.
      YN=YN+1.
      RETURN
C
400   FORMAT (/," FROM POINTr HEIGHT=",F10.4," KM,N=",I3,",NP=",I2,",REF
     1. INDEX ABOVE & BELOW X=",2E11.4,",IP=",I3,/,12X,"EQUIV. ABSORBER
     2AMOUNTS PER KM AT X=",4E10.3)
      END
```

```
**  NO ERRORS**    PROGRAM = 00766        COMMON = 01676
```

```
      FTN,L
      SUBROUTINE PTPTS(PP,TT,IMAX,KPTS)
      DIMENSION PP(9),TT(9),KPTS(3,40)
      COMMON TEMP(40),PRES(40)
C
C***** PROGRAM WRITTEN FOR 9 P,T POINTS
C
      DO 60 J=1,IMAX
      P0 = PRES(J)
      T0 = TEMP(J)
C     IF(ICALC2.GT.0) GO TO 50
C     ICALC2 = 1
C
C***** FIRST CALL AT GIVEN P,T---LOCATE INTERPOLATION POINTS
C
      IF(P0.GT.PP(5).AND.T0.GT.TT(5)) GO TO 15
      IF(P0.GT.PP(3)) GO TO 5
      K1 = 1
      K2 = 2
      K3 = 3
      IF(T0.LE.TT(2)) GO TO 50
      K1 = 4
      K2 = 3
      K3 = 2
      GO TO 50
 5    IF(P0.GT.PP(5)) GO TO 10
      K1 = 3
      K2 = 4
      K3 = 5
      IF(T0.LE.TT(5)) GO TO 50
      K1 = 6
      K2 = 5
      K3 = 4
      GO TO 50
 10   K1 = 6
      K2 = 5
      K3 = 7
      PMID = .5*(PP(5)+PP(7))
      IF(P0.LT.PMID) GO TO 50
      K1 = 8
      K2 = 7
      K3 = 5
      GO TO 50
 15   IF(P0.GT.PP(7)) GO TO 25
      K1 = 9
      K2 = 8
      K3 = 6
      IF(T0.GT.TT(6)) GO TO 50
      A6 = (T0-TT(6))**2+(P0-PP(6))**2
      A7 = (T0-TT(7))**2+(P0-PP(7))**2
      IF(A6.GT.A7) GO TO 20
      K1 = 5
      K2 = 6
      K3 = 8
      GO TO 50
 20   IF(T0.GE.TT(8)) GO TO 30
```

```
PAGE  0002  PTPTS   FTN4 COMPILER: HP24177  (SEPT. 1974)

      K1 = 8
      K2 = 7
      K3 = 5
      GO TO 50
25    TMID = .5*(TT(7)+TT(8))
      K1 = 8
      K2 = 7
      K3 = 5
      IF(T0.LE.TMID) GO TO 50
      K1 = 7
      K2 = 8
      K3 = 6
      GO TO 50
30    K1 = 9
      K2 = 8
      K3 = 6
50    CONTINUE
      KPTS(1,J) = K1
      KPTS(2,J) = K2
      KPTS(3,J) = K3
60    CONTINUE
      RETURN
      END

**  NO ERRORS**    PROGRAM = 00426      COMMON = 00160
```

```
PAGE  0001             FTN4 COMPILER: HP24177  (SEPT. 1974)

      FTN,L
      SUBROUTINE CALC2(V,T2)
      COMMON TEMP(40),PRES(40),V1,V2,DV,IRAD,LMAX,TAU(21)
      VI = V1
      VF = V1+DV
      DO 10 I=1,19
      IF(V.GE.V1.AND.V.LT.VF) GO TO 20
      VI = VI + DV
10    VF = VF + DV
20    T2 = TAU(I) + ((TAU(I+1)-TAU(I))/DV)*(V-VI)
      RETURN
      END
```

```
PAGE  0001             FTN4 COMPILER: HP24177  (SEPT. 1974)

      FTN,L
      FUNCTION ASIN(A)
      TEST = 1.0 - ABS(A)
      ARG = A/SQRT(1.-A**2)
      ASIN = ATAN(ARG)
      IF(TEST.LT.1.E-8) ASIN = 2.0*ATAN(1.0)
      RETURN
      END
```

```
PAGE  0001             FTN4 COMPILER: HP24177  (SEPT. 1974)

      FTN,L
      FUNCTION ACOS(A)
      ARG = SQRT(1.-A**2)/A
      ACOS = ATAN(ARG)
      IF(A.LT.1.E-8) ACOS = 2.0*ATAN(1.0)
      RETURN
      END
```

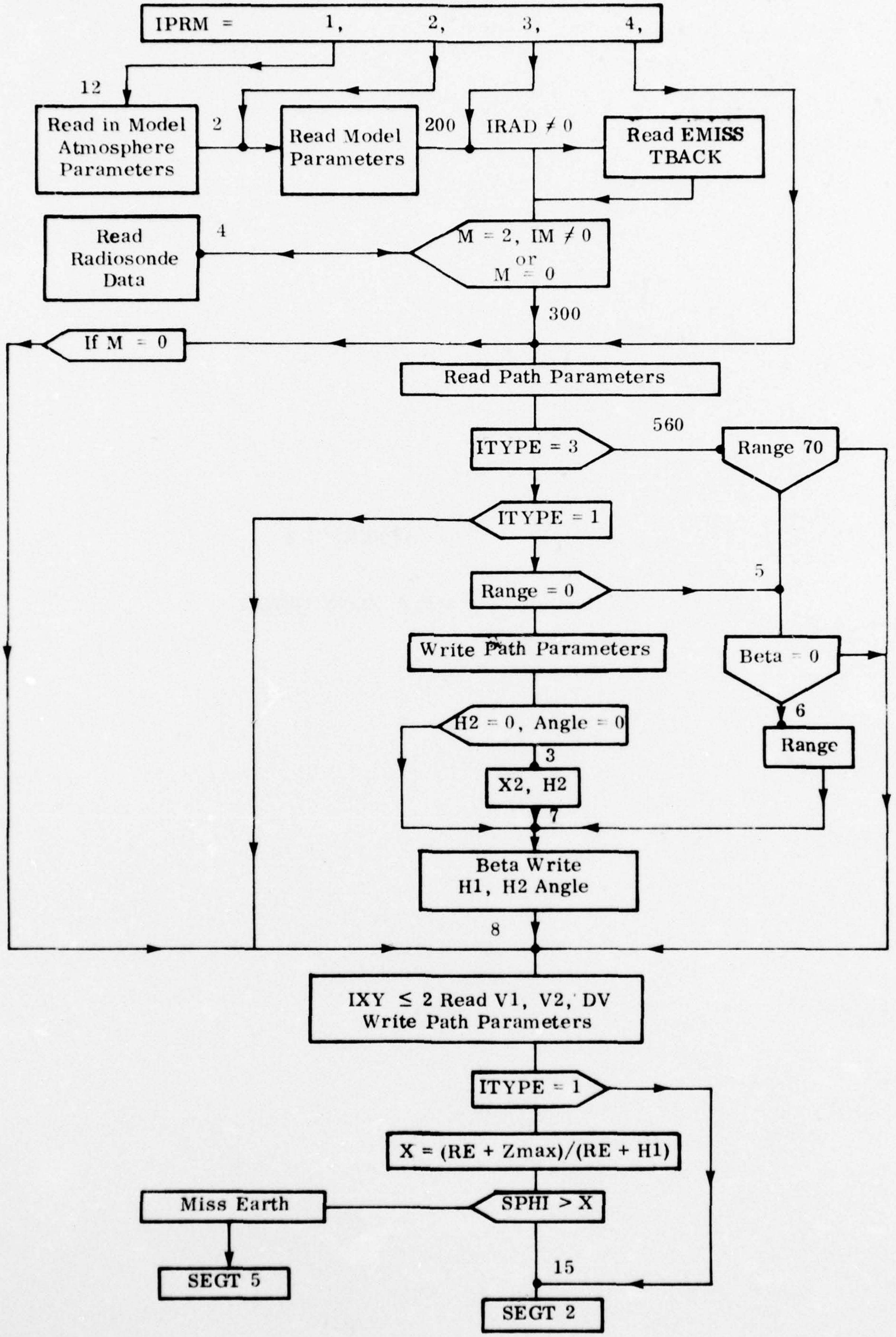
```
PAGE  0001             FTN4 COMPILER: HP24177  (SEPT. 1974)

      FTN,L
      FUNCTION F(A)
      F = EXP(18.9766-14.9595*A-2.43882*A*A)*A
      RETURN
      END
```

APPENDIX B

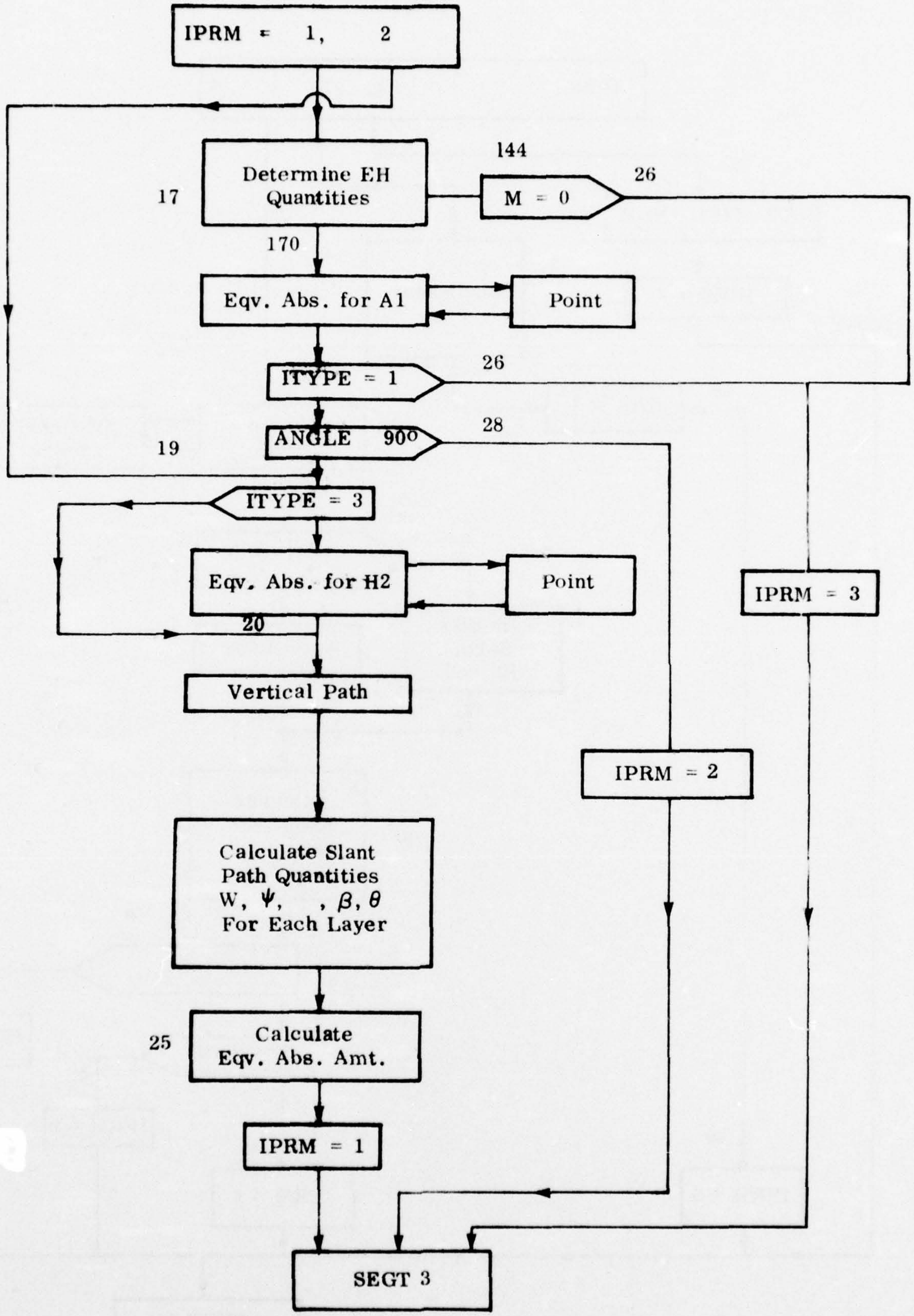
MRDA FLOW CHART

SEGT 1

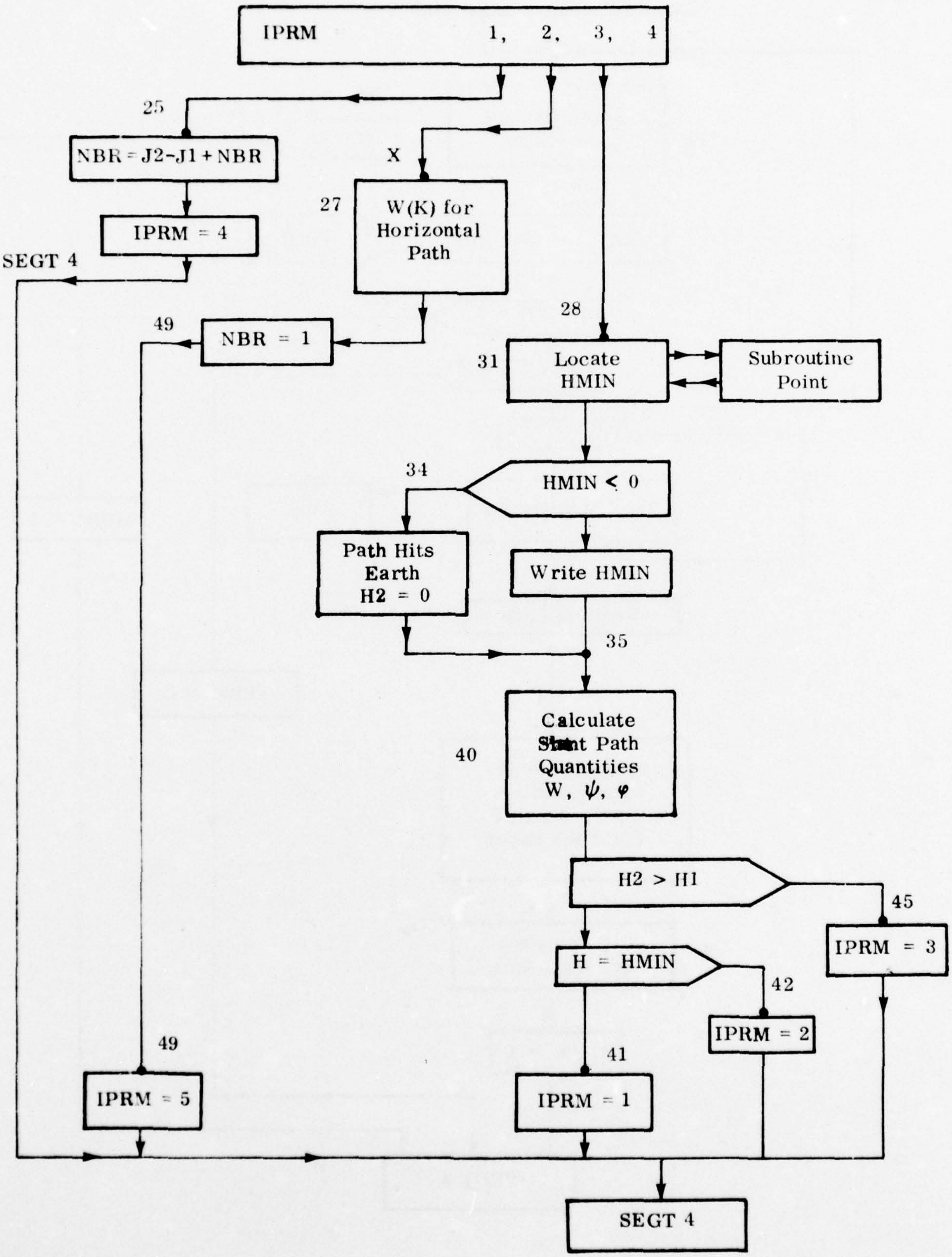


IPRM = 1, 2, 3, 4,
12
Read in Model Atmosphere Parameters
2
Read Model Parameters
200
IRAD ≠ 0
Read EMISS TBACK
Read Radiosonde Data
4
M = 2, IM ≠ 0 or M = 0
300
If M = 0
Read Path Parameters
560
ITYPE = 3
Range 70
8
ITYPE = 1
5
Range = 0
Write Path Parameters
Beta = 0
6
H2 = 0, Angle = 0
Range
3
X2, H2
7
Beta Write H1, H2 Angle
8
IXY ≤ 2 Read V1, V2, DV Write Path Parameters
ITYPE = 1
X = (RE + Zmax)/(RE + H1)
Miss Earth
SPHI > X
SEGT 5
15
SEGT 2

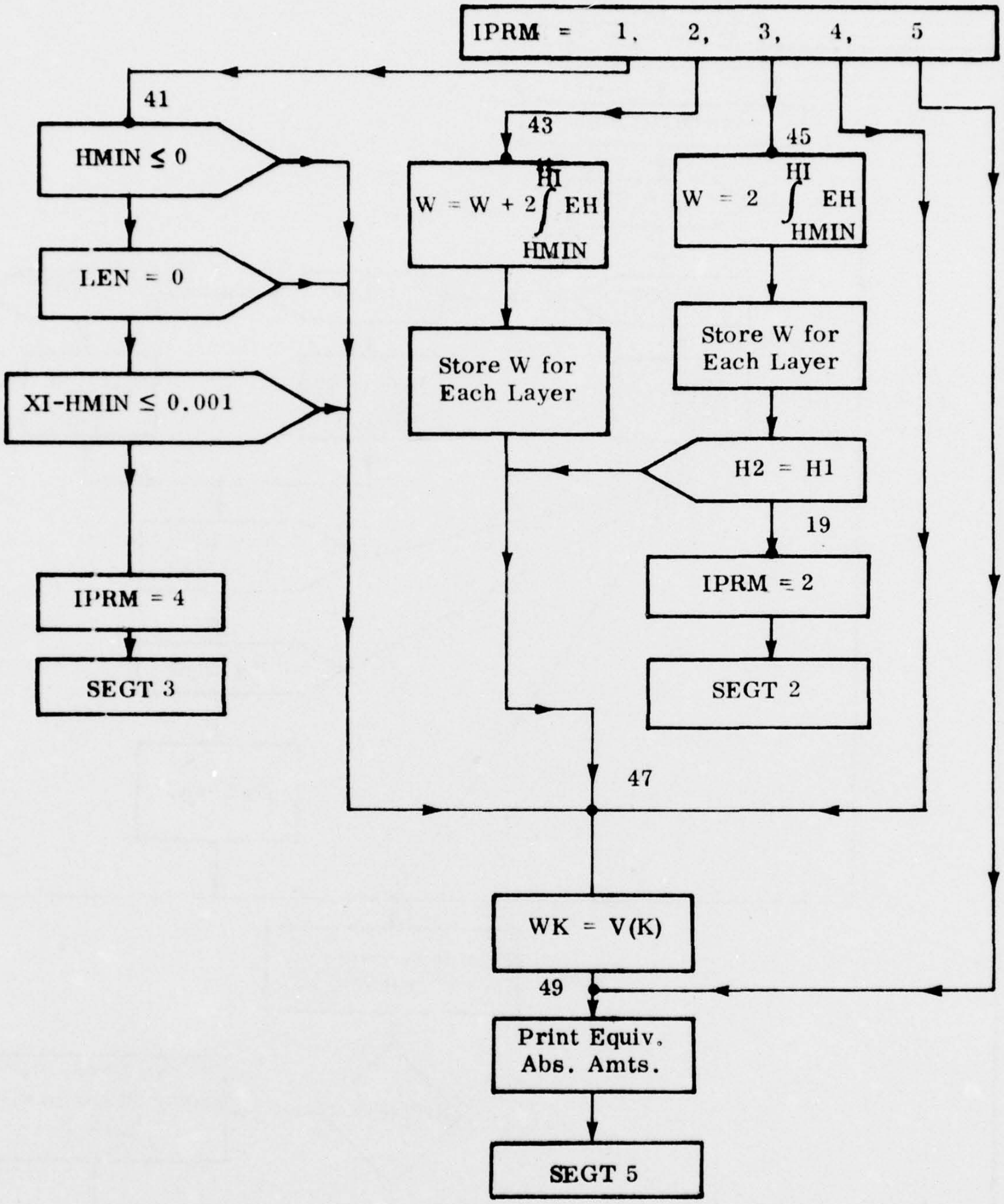
SEGT 2


IPRM = 1, 2
Determine EH Quantities
17
144
M = 0
26
170
Eqv. Abs. for A1
Point
26
ITYPE = 1
28
ANGLE 90°
19
ITYPE = 3
Eqv. Abs. for H2
Point
20
IPRM = 3
Vertical Path
IPRM = 2
Calculate Slant Path Quantities W, ψ, , β, θ For Each Layer
25
Calculate Eqv. Abs. Amt.
IPRM = 1
SEGT 3

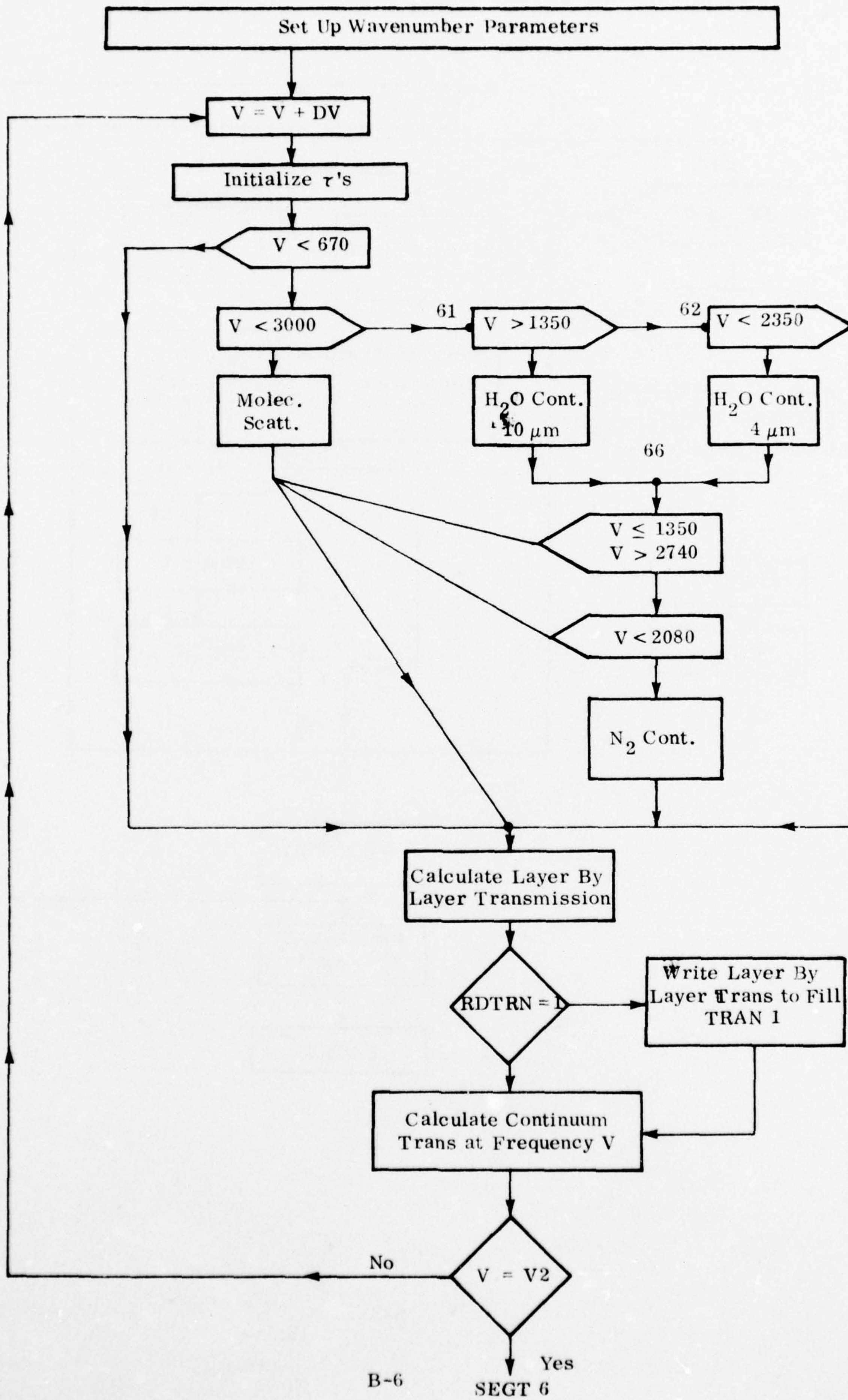
SEGT 3



IPRM 1, 2, 3, 4
25
NBR = J2-J1 + NBR
IPRM = 4
SEGT 4
X
27
W(K) for Horizontal Path
49
NBR = 1
28
31
Locate HMIN
Subroutine Point
34
HMIN < 0
Path Hits Earth H2 = 0
Write HMIN
35
40
Calculate Slant Path Quantities W, ψ, φ
H2 > H1
45
IPRM = 3
H = HMIN
42
IPRM = 2
49
IPRM = 5
41
IPRM = 1
SEGT 4

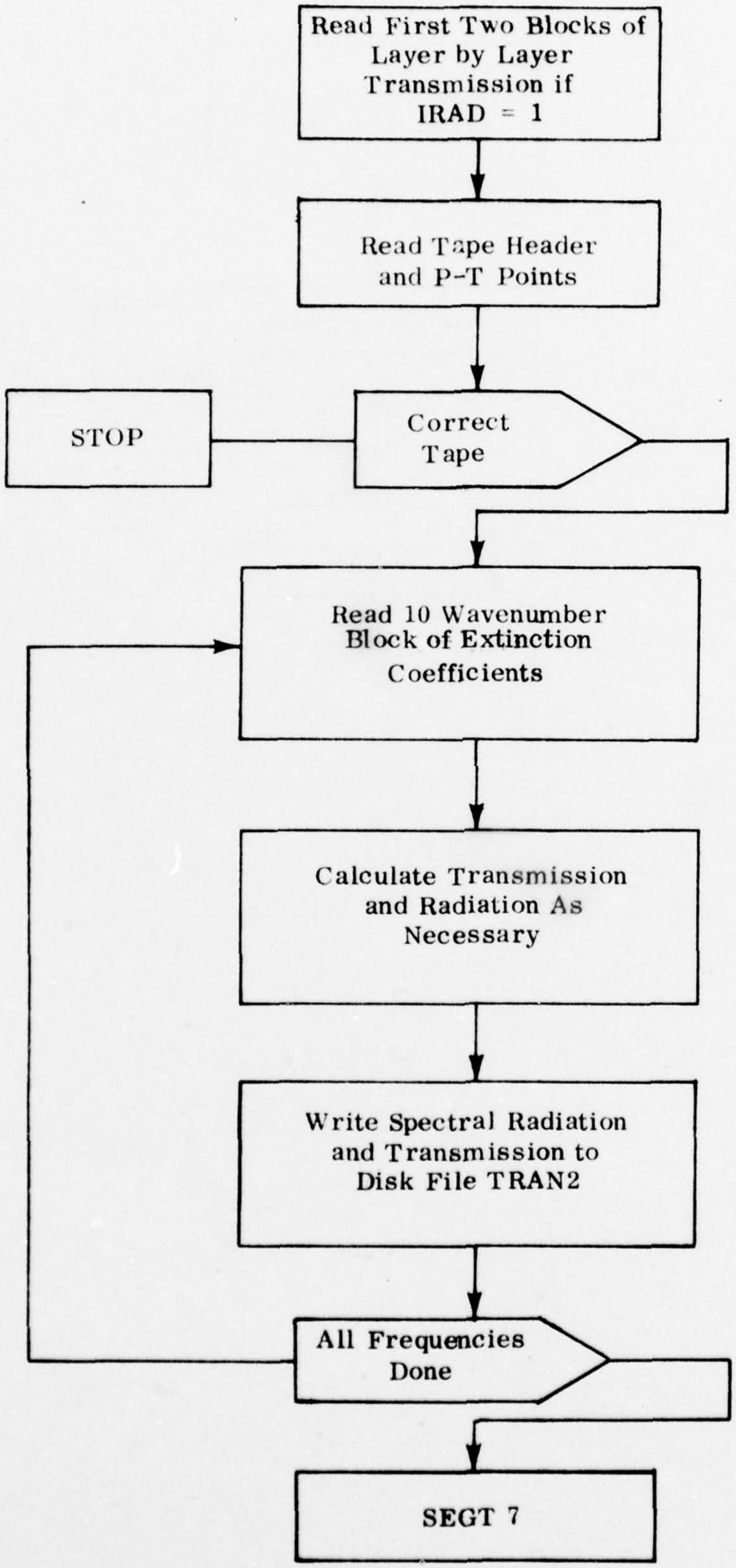

IPRM = 1, 2, 3, 4, 5
41
HMIN ≤ 0
LEN = 0
XI-HMIN ≤ 0.001
IPRM = 4
SEGT 3
43
W = W + 2 ∫ EH HI HMIN
Store W for Each Layer
45
W = 2 ∫ EH HI HMIN
Store W for Each Layer
H2 = H1
19
IPRM = 2
SEGT 2
47
WK = V(K)
49
Print Equiv. Abs. Amts.
SEGT 5

SEGT 5

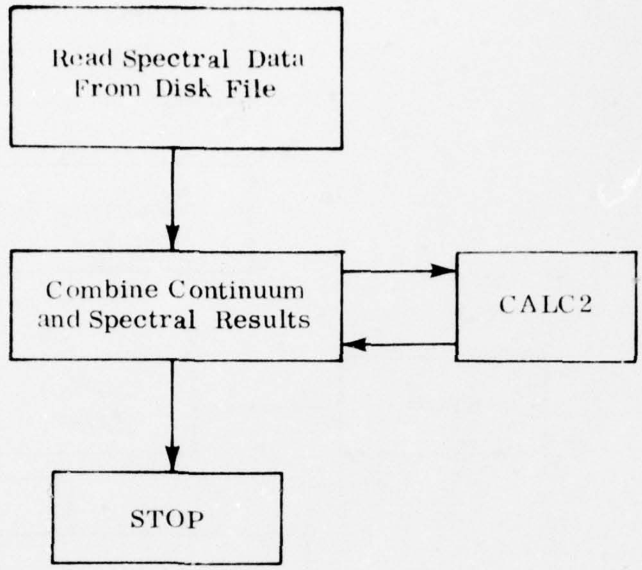


Set Up Wavenumber Parameters
V = V + DV
Initialize τ's
V < 670
V < 3000
61
V > 1350
62
V < 2350
Molec. Scatt.
H2O Cont. 10 μm
H2O Cont. 4 μm
66
V ≤ 1350
V > 2740
V < 2080
N2 Cont.
Calculate Layer By Layer Transmission
RDTRN = 1
Write Layer By Layer Trans to File TRAN 1
Calculate Continuum Trans at Frequency V
V = V2
No
Yes
SEGT 6

SEGT 6


Read First Two Blocks of Layer by Layer Transmission if IRAD = 1
Read Tape Header and P-T Points
STOP
Correct Tape
Read 10 Wavenumber Block of Extinction Coefficients
Calculate Transmission and Radiation As Necessary
Write Spectral Radiation and Transmission to Disk File TRAN2
All Frequencies Done
SEGT 7

SEGT 7


Read Spectral Data
From Disk File
Combine Continuum
and Spectral Results
CALC2
STOP

APPENDIX C

LIST OF SYMBOLS

SEGMENT 1

ALAM	Wavelength (μm)
ANGLE	Input zenith angle (degrees) (compare with θ_o in the text)
AVW	Average wavelength used in refractive index expression
BET	Angle subtended at the earth's center as path traverses adjacent levels (cf β_i in Eq. (8))
BETA	Total angle subtended by path at earth's center (compare β in Eq. (9)
CA	Conversion factor from degrees to radians
CO	Wavelength dependent coefficient used in refractive index expression
CW	Wavelength dependent coefficient used in refractive index expression
C7	Extinction coefficient for aerosol models
C7A	Aerosol absorption coefficient
DP	Dew point temperature (^oC)
DV	Wavenumber increment at which transmittance is calculated
HMIN	Minimum altitude of path trajectory (km)
H1	Initial altitude (km)
H2	Final altitude (km)
HZ1	Aerosol number density (no. cm^{-3}) for 23 km visual range
HZ2	Aerosol number density (no. cm^{-3}) for 5 km visual range
I	Running integer used as altitude (level) indicator and frequency indicator
IHAZE	Aerosol model indicator
IM	Parameter used when reading in a new atmospheric model (see Section 5.2.1)
IP	Indicator for using subroutine POINT to calculate refractive index only (IP = 0) or equivalent absorber amounts also (IP $\neq$ 0).
IPRM	Flag for segment communication
ITYPE	Indicator for type of atmospheric path (see Section 5.1)
IXY	Parameter for terminating program and cycling indicator
J	Running integer for altitude identification
JP	Print option parameter
J1	Level indicator for altitude H1
J2	Level indicator for altitude H2
L	Index for levels

LEN	Parameter used for defining longer of two paths (see Section 5.1)
M	Integer used to identify required model atmosphere
ML	Number of levels in radiosonde data input (MODEL = 2)
MODEL	Integer used to identify required model atmosphere (see Section 5.1)
NAME	ASCII Name of next segment to be called
NL	Number of levels in model atmosphere
NLDAT	Number of layers in model atmosphere data
P(I)	Pressure (mb) at level I
PI	3.141592654 that is (π)
RANGE	Path length (km)
RE	Earth radius (km)
RH	Relative humidity (%)
RI	The product of the sine of the initial zenith angle and the earth center distance to starting altitude
SPHI	Sine of the local zenith angle at a given level (cf sin θ)
SR	Slant range (km)
T(I)	Temperature (^{O}K) at level I
TBACK	Background radiation calculation temperature
TMP	Ambient temperature (^{O}C)
TT	Ratio 273.15/(TMP + 273.15)
VH(K)	Integral of the equivalent absorber amounts from H1 to level I
VIS	Visual range (km) at sea level
VX	Wavelength at which aerosol coefficients are read in (μm)
V1	Initial frequency for transmittance calculation, cm^{-1}
V2	Final frequency for transmittance calculation, cm^{-1}
WH(I)	Water vapor density at level I (gm m^{-3})
WO(I)	Ozone density at level I (gm m^{-3})
X	Input height to POINT subroutine
X1	Earth center distance of level I
X2	Earth center distance of level I + 1
Y	Input zenith angle in radians
Z(I)	Altitude at level I in km

SEGMENT 2

AHAZE	Aerosol number density for MODEL = 1
AHZ2	Aerosol number density for MODEL = 2
ALT(LL)	Altitude at level Z(LYR(LL))
ANGLE	Input zenith angle (degrees) (compare with θ_o in the text)
CO	Wavelength dependent coefficient used in refractive index expression
CW	Wavelength dependent coefficient used in refractive index expression
D	Water vapor amount (pr. cm/km) at level I
DS	Path length from level I to Level I + 1
DZ	Height increment from level I to level I + 1
EH	Equivalent absorber amounts
EV	Integrated absorber amount from level I to level I + 1
HAZE	Aerosol number density (no. cm^{-3})
H1	Initial Altitude
H2	Final Altitude
HZ1	Aerosol number density (no. cm^{-3}) for 23 km visual range
HZ2	Aerosol number density (no. cm^{-3}) for 5 km visual range
IHAZE	Aerosol model indicator
IP	Indicator for using subroutine POINT to calculate refractive index only (IP = 0) or equivalent absorber amounts also (IP $\neq$ 0).
IPRM	Flag for segment communication
ITYPE	Indicator for type of atmospheric path (see Section 5.1)
JP	Print option parameter
L	Frequency indicator for ozone transmittance calculation
LBR	Layer counting parameter for slant path trajectory
LL	Level index
LYR(LL)	Level number of Lth Layer in the atmospheric path
M	Integer used to identify model atmosphere

NAME	ASCII of next segment to be called
NL	Number of levels in model atmosphere data
NP1	Value of NP for altitude H1
PHI	Angle of arrival at H2
PS	Total pressure in atmospheres
PSI	Angular deviation of path from initial direction
PPW	Partial pressure H_2O
PRES(LL)	Pressure al level LL
PT	Product of total pressure (atm) and the square root of 273/T(M,I)
REF	Refractive index of air at level I
RN	Ratio of refractive indices of air above and below a given level
RX	Ratio of earth center distances between adjacent levels
SALP	Sine of angle of arrival at adjacent level
SPHI	Sine of the local zenith angle at a given level
SR	Slant range (km)
TEMP(LL)	Temperature at level LL
T(I)	Temperature (^oK) at level I
THETA	Zenith angle at a given level (in degrees)
TS	Ratio of standard temperature (273.0^{o}K) to temperature at level I
TX(K)	Equivalent absorber amounts per km at a giv en altitude obtained from POINT; also transmittance values at a given wavelength for each absorber type (K = 1, 8)
TX(9)	Total transmittance at frequency V
TX(10)	Absorption due to aerosol only at frequency V
TX1	Refractive index of layer above initial altitude H1
VIS	Visual range (km) at sea level
WH(I)	Water vapor density at level I (gm m^{-3})
WW	Equivalent absorber amount from observer to level L
W2	Water vapor density for atmospheric model M at level I + 1 (gm m^{-3})
X	Input height to POINT subroutine
X1	Earth center distance of level I
YN	Refractive index of layer below input height from POINT subroutine
Z(I)	Altitude at level I in km

SEGMENT 3

AL	Equivalent absorber amount per km at level L
ALT(LL)	Altitude of level LYR(LL)
AO	Constant A defined in Eq. (10) of LOWTRAN3 Manual
BET	Angle subtended at the earth's center as path traverses adjacent levels
BETA	Total angle subtended by path at earth's center
CA	Conversion factor from degrees to radians
DS	Path length from level I to Level I + 1
EV	Integrated absorber amount from level I to level I + 1
H	Altitude at which calculations are being made
HM	Estimated tangent height (km)
HMIN	Minimum altitude of path trajectory (km)
H1	Initial altitude
H2	Final altitude
I	Running integer used as altitude (level) indicator and frequency indicator
IP	Indicator for using subroutine POINT to calculate refractive index only (IP = 0) or equivalent absorber amounts also (IP $\neq$ 0).
IPRM	Flag for segment communication
JP	Print option parameter
K	Absorber indicator
K2	Cycling parameter for downward looking paths
L	Frequency indicator for transmittance calculation
LBR	Total Number of levels transversed in the path
LL	Level index
LMIN	Layer number of HMIN
LYR(LL)	Lth level in path
L1	Frequency identifier for transmittance calculation
L2	Frequency identifier for transmittance calculation

M	Integer used to identify required model atmosphere
NAME	Used to contain name of next segment called
NP1	Value of NP for altitude H1
NP2	Value of NP for altitude H2
P(I)	Pressure (mb) at level I
PRES(LL)	Pressure at level LL
PSI	Angular deviation of path from initial direction
Range	Path length (km)
RE	Earth radius (km)
REF	Refractive index of air at level I
RN	Ratio of refractive indices of air above and below a given level
RX	Ratio of earth center distances between adjacent levels
SALP	Sine of angle of arrival at adjacent level (cf sin α)
SPHI	Sine of the local zenith angle at a given level (cf sin θ)
SR	Slant range (km)
T(I)	Temperature (^{o}K) at level I
TEMP(LL)	Temperature at level LL
THET	Zenith angle at a given level (in radians)
THETA	Zenith angle at a given level (in degrees)
TMP	Ambient temperature (^{o}C)
TX(K)	Equivalent absorber amounts per km at a given altitude obtained from POINT; also transmittance values at a given wavelength for each absorber type (K = 1, 8)
TX(9)	Total transmittance at frequency V
TX(10)	Absorption due to aerosol only at frequency V
VH(K)	Integral of the equivalent absorber amounts from H1 to level I
W(K)	Total equivalent absorber amount for entire path
WW(K, L)	Equivalent absorber amount from observer to level LL
X	Input height to POINT subroutine
X2	Earth center distance of level I + 1
Y	Input zenith angle in radians
YN1	Refractive index of layer below initial altitude H1
YN2	Refractive index of layer below final altitude H2
Z(I)	Altitude at level I in km

SEGMENT 4

ALT(LL)	Altitude of layer L
B	Blackbody function
BETA	Total angle subtended by path at earth's center
CA	Conversion factor from degrees to radians
DV	Wavelength increment
E(K)	Equivalent absorber amounts per km at height H
H	Height
HM	Estimated height
HMIN	Minimum altitude of path tragectory
I	Frequency index
IPRM	Segment path indicator
IV1	Starting frequency
IV2	Last frequency
K2	Cycling parameter for downward path
L	Running index for layers
LBR	Layer counting parameters for slant path trajectories
LEN	Parameter used for defining longer of two paths
LL	Running index for levels
LLMIN	Value of LL at HMIN
LMAP	Counting variable for long path storage
LSTORE	Counting variable for layer index
LYR(LL)	Altitude of Lth layer in path
L2	Layer number of H2
NAME(3)	Used to identify next segment to be called
P(L)	Pressure at layer L
PH	Angle of arrival at H2
PMIN	Pressure at HMIN
PRES(LL)	Atmospheric pressure at layer L

PS	Total pressure in atmospheres
PSI	Angular deviation of path from initial direction
RN	Ratio of refractive indicies of Air above and below a given level
SPHI	Sine of local zenith angle at a given level
SR	Slant Range
T(L)	Temperature at layer L
TEMP(LL)	Temperature at layer LL
TMIN	Temperature at HMIN
TS	Ratio of standard temperature to temperature at level L
TX1	Refractive index of layer above initial altitude H1
VI	Initial frequency
VH(K)	Integral of the equivalent absorber amounts from H1 to level I
W(K)	Total equivalent absorber amount for entire path
WW(LL, K)	Equivalent absorber amounts from observer to level LL
X1	Earth center distance of level L
X2	Earth center distance of level L + 1
YN1	Refractive index of layer below initial altitude H1

SEGMENT 5

AB	Absorption at frequency V; also average transmittance
ALAM-	Wavelength (μm)
C4	Absorption coefficient for nitrogen ($\sim 4 \mu$m)
C5	Absorption coefficient for water vapor continuum
C6	Extenction coefficient for molecular scattering
C7	Extenction coefficient for aerosol models
C7A	Aerosol absorption coefficient
DV	Wavelength increment
IDV	Frequency increment
IHAZE	Aerosol model indicator
INDEX	Counting variable for frequency
IPRM	Segment path indicator
IRAD	Radiation calculation flag
IV	Frequency of calculations
IV1	Starting frequency
IV2	Last frequency
JP	Print option parameter
K4	Frequency indicator for nitrogen continuum transmission calculation
LL	Running index for level s
LMAX	Number of layers in the path
LOOP	Number of layers for low resolution radiance calculations
NAME	Used to idenfity next segment to be called
NH	Frequency indicator for water vapor continuum transmittance calculation
SUM	Sum of optical thicknesses of absorbers 4 through 8
SUMA	Accumulated integrated absorption
TAU (INDEX)	Transmittance
TRAN1 (LL)	Transmittance of layer LL

TX(K)	Equivalent absorber amounts per km at a given altitude obtained from POINT; also transmittance values at a given wavelength for each absorber (K = 1 , 4)
TX(5)	Total transmittance at frequency V
TX(6)	Absorption due to aerosol at frequency V
VH(K)	Integral of the equivalent absorber amounts from H1 to level I
VX	Wavelength of aerosol coefficients
W(K)	Total equivalent absorber amount for entire path
WGAS(LL)	Atmospheric gas density
WHZO(LL)	H_2O density
WO3(LL)	O_3 density
WW(LL, K)	Equivalent absorber amounts from observer to level LL
XD	Wavenumber interpolation parameter
XH	Wavenumber interpolation parameter in H_2O continuum calculation
XI	Wavenumber interpolation parameter
XX	Aerosol extinction coefficient
YY	Aerosol absorption coefficient of frequency V

SEGMENT 6

AK(K, N)	Extinction coefficient read from tape for Kth pressure-temperature point at frequency VV(N)
AKK	Interpolated extinction coefficient
BUF(63)	Disk write buffer containing frequency plus spectral transmission & radiance results
CON(6)	Species concentrations
DIST	Optical depth of a species
DVM	MRDA frequency interval
FAC1	Log transmittance
FAC2	Summing variable for transmittance
FAC4	Log transmittance for radiation
FAC5	Log transmittance for radiation
FP	Intermediate result in interpolation of AK(K, N)
FT	Intermediate result in interpolation of AK(K, N)
ILP	Integer variable for printing heading
IRAD	Radiation calculation flag
KPTS(3, LL)	Elements in P-T matrix used for AK interpolation
MSPEC	Number of species
M1	Index for locating extinction coefficient on tape
N	Frequency index
NAME(3)	ASCII name of next segment to be called
NMAX	Upper limit on index for input of W(N) and AK(K, N) for a particular species
NMIN	Lower limit on index for input of W(N) and AK(K, N) for a particular species
NPT	Number of points in the pressure temperature matrix
NVM(M)	Element in AK(K, N) & W(N) where the Mth Species information begins
NI	Index for locating extinction coefficient
PBAR	Pressure variable (PBAR $\geq$ 75 mb)

PLANK	Black body radiation from BLAM
PP(K)	Pressure array read from tape
PRES(LL)	Pressure at layer LL
RAD	Radiation result
RAD1	Spectral radiation
RV1	Frequency corresponding to information in TRAN1(LL)
RV2	Frequency corresponding to informtion in TRAN2(LL)
SPEC(M,2)	ASCII abreviation of Mth specie
TRAN	Total transmission
TRAN1(LL)	Buffer used to read continuum radiation from disk for layer LL
TRAN2(LL)	Buffer used to read continuum radiation from disk for layer LL
TT(K)	Temperature array read from tape
VA	Initial frequency in tape data block
VB	Final frequency in tape data block
VCHK	Used to compare lower frequency of tape data block with calculation frequency
VCHK2	Used to compare upper frequency of tape data block with calculati frequency
VMAX	Max frequency contained in tape
VMIN	Minimum frequency contained in tape
VO	Initial calculational frequency
V1	Initial calculational frequency
V2	Final calculational frequency
VV(N)	Frequency array read from tape
VV1	Used in interpolating tape input frequencies to calculation frequen
VV2	Used in interpolating tape input frequencies to calculating frequen
WGAS(LL)	Gas concentration
WH20(LL)	Water vapor concentration
WO3(LL)	Ozone concentration
YO	Used in interpolating AK
Z(I)	Altitude

SEGMENT 7

BUF(I)	Buffer containing frequency plus specular radiation and transmission results
IK	Running index for frequency
IRAD	Radiation calculation flag
LEN	Number of frequencies read from disk in one read
NUMV	Total length of V(IK) array
TR(1, IK)	Combined continuum and spectral transmission
TR(2,IK)	Combined continuum and spectral radiation
V(IK)	Frequency corresponding to TR(I,IK)

APPENDIX D

```
      PROGRAM LBL(INPUT,OUTPUT,TAPE2,TAPE4,TAPE5=INPUT)
C
C     8 OCTOBER 76      HITRAN MODIFIED FOR MRDA
C
C
      DIMENSION W(7), GNU(5000), S(5000), ALPHA(5000), EDP(5000)
      DIMENSION MOL(5000),VSTOR(403),STOR(9,304),P(10),T(11)
      DIMENSION CS2(9),OMEGA(201,6),JCALC(6),SO(5000),ALPHA0(5000)
      DIMENSION TI(250,12),TTI(250),SPECIE(7),DENS(6)
      LOGICAL LOGIC
      DATA SPECIE/3HH2O,3HCO2,2HO3,3HN2O,2HCO,3HCH4,2HO2/
C
C
      REWIND 2
      IEOF=0
      DEPTH=0.001
      PI=3.14159
C
      VBLOCK=10.
      BREIT=.06
      BRT2=2.2*BREIT
      SLOWER=1.0E-23
C
      READ(5,76) NPTPTS
   76 FORMAT(I2)
      READ(5,77) (P(I),I=1,NPTPTS)
   77 FORMAT(8(E10.0))
      READ(5,77) (T(I),I=1,NPTPTS)
      PRINT 82,(P(I),I=1,NPTPTS)
   82 FORMAT(* PRESSURE=*,5(2X,F7.2)/10X,5(2X,F7.2))
      PRINT 84, (T(I),I=1,NPTPTS)
   84 FORMAT(* TEMPERATURE=*,5(2X,F7.2)/13X,5(2X,F7.2))
      IF(EOF(5).NE.0) STOP 20
      READ 81, (W(M),M=1,7)
   81 FORMAT(7E10.3)
      PRINT 83
   83 FORMAT(3X,*WATER*,6X,*CO2*,6X,*OZONE*,7X,*N2O *,7X,*CO*,8X,*CH4*,
     17X,*O2*,4X)
      PRINT 81, (W(M),M=1,7)
      READ 85, V1,VV2,DV,BOUND
   85 FORMAT(6F10.3)
      PRINT 87, V1,VV2,DV,BOUND
```

```
   87 FORMAT(* V1 =*,F10.3,* V2 =*,F10.3,* DV=*,F10.3,* BOUND =*,F10.3)
C      WRITE(10,120) V1,VV2,NPTPTS
       WRITE(4,120) V1,VV2,NPTPTS
  120 FORMAT(2(F10.2),I5)
       IF(V1.GE.VV2) STOP 21
C      WRITE(10,130) (P(I),I=1,NPTPTS)
       WRITE(4,131) (P(I),I=1,NPTPTS)
C      WRITE(10,130) (T(I),I=1,NPTPTS)
       WRITE(4,131) (T(I),I=1,NPTPTS)
  130 FORMAT((5(F10.2)))
  131 FORMAT((9(F10.2)))
C
C      LOOP BACK POINT --- READ MORE LINES FROM THE TAPE
  999 V2=V1+VBLOCK
       IF(V2.GT.VV2) V2=VV2
       VBOT=V1-BOUND
       VTOP=V2+BOUND
       VVTOP=VV2+BOUND
C
C      WE ARE NOW READY TO READ TAPE.
C
       I=1
       ILL=1
       NEOF=0
       REWIND 2
1      READ(2)TMIN,TMAX,NIREC,((TI(I1,J1),J1=1,12),ITI(I1),I1=1,NIREC)
       JTO=IOCHEC(2)
       IF(JTO)4,2
4      PRINT 89,GNU(I)
   89 FORMAT(* PARITY ERROR ENCOUNTERED AT*,F12.3)
       GO TO 1
2      IF(EOF(2))5,7
5      IEOF=IEOF+1
       NEOF=NEOF+1
       PRINT 91,IEOF,TMIN,TMAX,NIREC
   91 FORMAT(* END OF FILE ENCOUNTERED*,I5,2F12.3,I5)
       IF(NEOF.GT.2) STOP 22
       GO TO 1
    7  NEOF=0
       IF(TMAX.LT.VBOT)GO TO 1
       DO 9 K=1,NIREC
       IF(TI(K,1).LT.VBOT)GO TO 9
       GNU(I)=TI(K,1)
       S(I)=TI(K,2)
       ALPHA(I)=TI(K,3)
       EDP(I)=TI(K,4)
       MOL(I)=ITI(K)
       M=MOL(I)
       SMIN=S(I)*DENS(M)
       IF(SMIN.LE.1.0E-24) GO TO 9
       IF(GNU(I).GT.VVTOP)GO TO 11
       I=I+1
9      CONTINUE
C
C  MAXIMUM NUMBER OF LINES
C
       IF(I.LT.4750)GO TO 1
```

```
      I=I-1
11    I1=I
      PRINT 97, VBOT,VVTOP,GNU(I1),I1
   97 FORMAT(* VBOT =*,F12.3,*VVTOP =*,F12.3,*GNU =*,F12.3,* I1 *,I8)
C
C     SUPPLY HALFWIDTHS WHEN NOT ON TAPE
C
      DO 15 I=ILL,I1
      MM=MOL(I)
      IF(MM.EQ.1) GO TO 15
      IF(ALPHA(I).GT.0.0) GO TO 13
      IF(MM.EQ.2) ALPHA(I)=0.07
      IF(MM.EQ.3) ALPHA(I)=0.11
      IF(MM.EQ.4) ALPHA(I)=0.08
      IF(MM.EQ.5) ALPHA(I)=0.05
      IF(MM.EQ.6) ALPHA(I)=0.055
      IF(MM.EQ.7) ALPHA(I)=0.048
   13 IF(ALPHA(I).LT.0.01.OR.ALPHA(I).GT.1.0) ALPHA(I)=0.06
   15 CONTINUE
C
C      CALCULATE THE ABSORPTION COEFFICIENTS AT THE 50 MOST INTENSE CO2 LINES
C       AND AT 3 POINTS INBETWEEN
C
C     LOOP BACK POINT  ---  DON'T NEED TO READ TAPE
C
  300 CONTINUE
C     WRITE(10,120) V1,V2
      WRITE(4,120) V1,V2
      DATA DENS/1.0,1.0,1.0E-2,1.0E-3,.5E-3,.5E-2/
      DO 312 JC=1,I1
      IF(GNU(JC).GE.V1) GO TO 313
  312 CONTINUE
  313 IMIN=JC
      DO 314 JC=IMIN,I1
      IF(GNU(JC).GT.V2) GO TO 315
  314 CONTINUE
  315 IMAX=JC-1
C
C
      FAC=1.0E-20
      JLOOP=0
  309 JLOOP=JLOOP+1
      JPTS=0
      FAC=.3*FAC
      IMAX=IMAX+1
      GSTOR=GNU(IMAX)
      SSTOR=S(IMAX)
      MSTOR=MOL(IMAX)
      GNU(IMAX)=V2
      S(IMAX)=1.0
      DO 370 M=1,6
      MOL(IMAX)=M
      OMEGA(1,M)=V1
      SMIN=FAC*DENS(M)
  310 JCNT=1
      DO 320 JC=IMIN,IMAX
      IF(MOL(JC).NE.M) GO TO 320
```

```
      IF(S(JC).LT.SMIN) GO TO 320
      OLAST=OMEGA(JCNT,M)
      FAC1=20.*GNU(JC)
      IFF=FAC1
      ONEW=IFF/20.
      IF((FAC1-IFF).GT.0.5) ONEW=ONEW+0.05
      IDELT=20.*(ONEW-OLAST)
      IF(IDELT-1) 320,343,344
  343 JCNT=JCNT+1
      GO TO 319
  344 OMEGA(JCNT+1,M)=OLAST+0.05
      IF(IDELT-3) 345,316,317
  345 JCNT=JCNT+2
      GO TO 319
  316 OMEGA(JCNT+2,M)=OLAST+0.10
      JCNT=JCNT+3
      GO TO 319
  317 OMEGA(JCNT+2,M)=.5*(OLAST+ONEW)
      OMEGA(JCNT+3,M)=ONEW-0.05
      JCNT=JCNT+4
  319 OMEGA(JCNT,M)=ONEW
  320 CONTINUE
      JCALC(M)=JCNT
  370 JPTS=JPTS+JCALC(M)
      GNU(IMAX)=GSTOR
      S(IMAX)=SSTOR
      MOL(IMAX)=MSTOR
      IMAX=IMAX-1
      IF((JLOOP.GE.60).AND.(JPTS.GT.240)) GO TO 371
      IF((JPTS.LT.170).AND.(FAC.GE.SLOWER)) GO TO 309
      IF(JPTS.LT.240) GO TO 321
  371 FAC=4.*FAC
      GO TO 309
C
C
  321 CONTINUE
      ICOUNT=0
      DO 240 M=1,6
      JMAX=JCALC(M)
      JNONE=5
      IF(JMAX.GT.JNONE) GO TO 330
C
C
C     NO STRONG LINES IN THIS BLOCK
C
      OMEGA(4,M)=(OMEGA(5,M)+OMEGA(3,M))/2.
      OMEGA(2,M)=(OMEGA(3,M)+OMEGA(1,M))/2.
      PRINT 339,JLOOP,FAC,SPECIE(M),(OMEGA(JJ,M),JJ=1,JMAX)
  339 FORMAT(//* NO INTENSE LINES*,10X,*JLOOP=*,I4,
     $10X,*SMIN=*,E10.3,12X,*SPECIES=*,A10/
     $* OMEGA=*,5F14.3)
      GO TO 338
C
C     STRONG LINES IN THIS BLOCK
C
  330 CONTINUE
      PRINT 325,JMAX,JLOOP,FAC,SPECIE(M)
```

```
  325 FORMAT (//I10,*  CALCULATIONAL POINTS:*,10X,*JLOOP=*,I3,5X,
     **SMIN=*,E10.3,10X,A10/9X,*VALUES OF OMEGA*)
      PRINT 326,(OMEGA(JJ,M),JJ=1,JMAX)
  326 FORMAT(10F10.3)
  338 CONTINUE
      LOGIC=.FALSE.
      IF(M.EQ.1.OR.M.EQ.3.OR.M.EQ.6) LOGIC=.TRUE.
C
C     PRESSURE, TEMPERATURE LOOP
C
C
      P0=1013.00
      T0=296.00
      NPT=0
C
C     BRANCH BACK POINT FOR (P,T) LOOP
C
  350 NPT=NPT+1
      I5=1
      CS1=(T0-T(NPT))/(T0*T(NPT)*0.6946)
C
C     ROTATIONAL PARTITION FUNCTION IS DEFINED BELOW
C
      WT=SQRT(T0/T(NPT))
      CS2(M)=T0/T(NPT)
      IF(LOGIC) CS2(M)=CS2(M)*WT
      CA=WT*P(NPT)/P0
C
C     TEMPERATURE DEPENDENCE OF ALL LINE INTENSITIES COMPUTED HERE.
C
      DO 23 I=ILL,I1
      IF(MOL(I).NE.M) GO TO 23
      SO(I)=S(I)*CS2(M)*EXP(-EDP(I)*CS1)
      ALPHAO(I)=ALPHA(I)*CA
   23 CONTINUE
C
      DO 555 JJ=1,JMAX
      V=OMEGA(JJ,M)
C
      CAY1=0.0
27    SUM1=0.0
C
C     DETERMINE INDICES (I5 AND I6) INDICATING WHICH SPECTRAL LINES
C     ARE TO BE USED IN THE CALCULATION AT FREQUENCY V.
C
      DO 33 I=I5,I1
      IF (V-BOUND-GNU(I)) 29,29,33
29    I5=I
      GO TO 35
33    CONTINUE
      I5=I1
      GO TO 555
35    DO 39 J=I5,I1
      IF (V+BOUND-GNU(J)) 37,37,39
37    I6=J-1
      GO TO 43
39    CONTINUE
```

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```
      I6=I1
C
C     COMPUTE THE OPTICAL DEPTH AND TRANSMITTANCE AT FREQUENCY V.
C
      DV=0.05
   43 DO 45 I=I5,I6
      IF (MOL(I).NE.M) GO TO 45
      Z=V-GNU(I)
      AL=ALPHAO(I)
C     IF(ABS(Z).GE.0.05) GO TO 88
C     IF(AL.GT.0.05) GO TO 88
C
C     ARCTAN FORMULA
C
C     SUM1=SO(I)/DV*(ATAN2(Z+DV/2.,AL)-ATAN2(Z-DV/2.,AL))
C     GO TO 44
C
C     LORENTZ FORMULA
C
   88 SUM1=SO(I)*AL*(.25/((Z-DV/2.)**2+AL*AL)
     &+.50/(Z*Z+AL*AL)+.25/((Z+DV/2.)**2+AL*AL))
   44 CAY1=CAY1+SUM1
   45 CONTINUE
      VSTOR(JJ)=.3183*CAY1*W(M)
  555 CONTINUE
C
      DO 557 JJ=1,JMAX
  557 STOR(NPT,JJ)=VSTOR(JJ)
C
  565 IF (NPT.LT.NPTPTS) GO TO 350
C
C     WRITE MRDA TABLE
C
C     WRITE(10,220) SPECIE(M),JMAX
      WRITE(4,221) SPECIE(M),JMAX
  220 FORMAT(1X,A4,I5)
  221 FORMAT(A4,I5)
      DO 230 JJ=1,JMAX
      ICOUNT=ICOUNT+1
      IF ((ICOUNT.GE.240).AND.(JMAX.NE.2)) GO TO 230
C     WRITE(10,225) OMEGA(JJ,M),(STOR(NPT,JJ),NPT=1,NPTPTS)
      WRITE(4,226) OMEGA(JJ,M),(STOR(NPT,JJ),NPT=1,NPTPTS)
  225 FORMAT(F12.2,4(E12.6)/5(E12.6))
  226 FORMAT(F12.2,9(E12.6))
  230 CONTINUE
  240 CONTINUE
      V1=V1+VBLOCK
      IF(V1.GE.VV2) STOP 23
      VTOP=V1+VBLOCK+BOUND
      IF(VTOP.GT.GNU(I1)) GO TO 999
      V2=V1+VBLOCK
      VBOT=V1-BOUND
      GO TO 300
C
      END
```